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THE KANGERDLUGSSUAK REGION OF EAST GREENLAND

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THE highest mountains in Greenland are to be found along the east coast between latitude 65° and 73° north. Petermann Peak (9650 ft.), first seen from a distance by the German Arctic Expedition 1869–70, stands at the north end of this stretch. It was climbed in 1929 by Mr. Wordie's party and its height accurately fixed. In the southern part the highest peak is Mount Forel (11,100 ft.), discovered by de Quervain in 1912 and surveyed, though not climbed to the top, during Watkins' expedition in 1930–31. Both these peaks at different times had been thought to be the highest land in Greenland, but in 1930 Watkins saw from the air just north of Kangerdlugssuak a range of mountains which he believed would one day be found to be higher than either.

There is great diversity in the topography of the high mountain zone. The northern third, composed of rocks of varying ages and kinds, is intersected by the finest fjord system in the world. The central part between Scoresby Sound and Kangerdlugssuak, which includes the mountains seen by Watkins and since named after him, is composed of Tertiary basalts, and is one of the least indented parts of the whole Greenland coast. The southern third, consisting for the most part of ancient gneisses and schists, has fjords of moderate length, and numerous islands off the coast.

The differences in the nature of the coast have been the chief factors influencing Eskimo migration, and they have also affected the order of its investigation by Europeans. It seems that the tidal currents formed at the entrances to the large fjords of the northern section break up the polar pack-ice lying off the coast, and aid the approach of ships to land. Ever since William Scoresby's discoveries in 1822 the northern fjord region has been the scene of a succession of expeditions. The Angmagssalik district to the south was first reached in 1883 by two separate expeditions under Gustav Holm and A. E. Nordenskiöld: in normal years the belt of pack-ice as far south as this

is narrow and ships have no great difficulty in getting through to the coast. The central stretch of coast has always proved more difficult to reach. Admiral Amdrup made the first journey along it in an open boat in 1900 and produced an excellent map of the outer coast. No other attempt was made to visit it until 1930, when the British Arctic Air Route Expedition led by Watkins worked up the coast from Angmagssalik to Kangerdlugssuak and explored this fjord for the first time. From the size of the entrance, which had been seen by Amdrup, and the information contained in the traditions of the Angmagssalik Eskimo, the fjord was believed to be large. When it was mapped by the Watkins expedition it was found to be 40 miles long, and thus only a third the size of Scoresby Sound, the largest of the fjords to the north.

Prior to 1930 no geologist had visited Kangerdlugssuak or the coast for 200 miles to the north and south, and Amdrup had observed there only basalt and gneiss. I was therefore pleasantly surprised during the British Arctic Air Route Expedition to find as well as these rocks an impressive series of plutonic intrusions comparable with those forming Skye, Rum, Mull, Arran, and parts of north-west Ireland, and like them belonging to the North Atlantic Tertiary Igneous Province. During the last thirty years the British Tertiary igneous rocks have been studied intensively by the officers of the Geological Survey and others, and data of great scientific interest on the nature of volcanic and deep-seated igneous action obtained. The Kangerdlugssuak igneous rocks lay outside the real sphere of action of the British Arctic Air Route Expedition, and could only be examined during ten days of the first summer. The interesting rock known as nepheline syenite was however found there. This suggested that minerals of economic importance—perhaps cryolite, which is mined in South-West Greenland and provides much of the revenue for the administration of the whole country—might be found in this region also. When in 1932 Captain Ejnar Mikkelsen decided to take a summer expedition to the Blossville coast and Kangerdlugssuak, one of the main reasons was to continue the geological work, and this I was generously invited to do. With the help of Dr. Jens Jensen and my brother, H. G. Wager, a month, during which we had almost continuous good weather, was spent at work in Kangerdlugssuak. No minerals of economic value were found, but this further work showed what a magnificent opportunity the region afforded for the study of Tertiary igneous activity because of the steepness of the mountains and the absence of vegetation.

On returning I at once began to plan an expedition for 1935–36 which would allow a prolonged attack on the geological problems of the Kangerdlugssuak region to be made. To avoid the heavy cost of chartering a vessel for two successive summers, the expedition was to go to Scoresby Sound on the Danish Government boat and in the early spring of the next year cross overland to Kangerdlugssuak, passing the Watkins Mountains on the way and if possible climbing them. The rest of the spring and summer was to be spent at work in the Kangerdlugssuak neighbourhood. In the summer of 1934 Dr. Charcot invited me to accompany him on the *Pourquoi Pas?* It was his custom to sail northward every summer and carry out some piece of exploration or scientific work. On this occasion he hoped, among other things, to reach the coast of Greenland near the Watkins Mountains and

possibly climb them, and he also agreed to take food and a boat to be put down in Kangerdlugssuak for my forthcoming expedition. Owing to a series of minor setbacks and the difficult ice conditions neither of these two objectives was attained, but I shall always remember with pleasure the time I spent on the *Pourquoi Pas?* in the company of Dr. Charcot, who was one of the kindest and most charming men it has been my fortune to meet.

Then came a considerable change in plans. Augustine Courtauld made the suggestion that he and I should co-operate in a summer attempt to reach the Watkins Mountains. This I was very ready to do, as my own plan only allowed the region to be visited during a long spring journey, when conditions might well be difficult. On 4 July 1935 our combined parties left Aberdeen for East Greenland. The approach to the coast, the journey north to Kangerdlugssuak, and the summer expedition to the Watkins Mountains, the highest point of which we succeeded in climbing, have already been described to this Society.[1] Co-operation with Courtauld not only resulted in a successful summer journey, but it also made it possible for the winter party to have Kangerdlugssuak as a permanent base in the midst of the country where the most important geological work lay. The enormous advantage of this became increasingly apparent as the year progressed.

I shall add nothing to Courtauld's admirable account of the summer activities of the expedition, but take up the story from the day on which the *Quest* left Kangerdlugssuak for England with the summer party on board. After the journey to the Watkins Mountains the main work of the expedition consisted of detailed geological and botanical investigations in the Kangerdlugssuak region. The present account is concerned mainly with the conditions in Kangerdlugssuak throughout the year, and with general observations made during journeys; specialized geological and botanical results will only be lightly touched upon.

Autumn and mid-winter

When the *Quest* left in the early morning of 29 August 1935, we scrambled on to a rounded hillock of bare rock already hot in the morning sun. From there we watched the ship cross the Sound and gracefully thread her way between a fixed iceberg and the land, and so pass out into the main fjord. After the ship had disappeared from our sight among the large bergs she gave the usual three whistles on her siren. We and the Eskimo replied with rifle shots and then scrambled down the rock to begin the next stage of our work.

The wintering party consisted of seven Europeans and fourteen Eskimo. The Europeans were: P. B. Chambers, general assistant for the geological parties and responsible for the zoological collecting; W. A. Deer, the second geologist; Dr. E. C. Fountaine, medical officer, mountaineer, and also responsible for any survey that was required; Dr. H. G. Wager, botanist; Mrs. H. G. Wager, mainly employed as assistant botanist; L. R. Wager, geologist; and Mrs. L. R. Wager, responsible for all domestic matters and sometimes assisting with the geological work. The fourteen Eskimo were the families and dependants of Enoch and Hansi. Enoch, the best hunter of the Cape Dan settlement in the Angmagssalik District, had wintered near

[1] *Geogr. J.* 88 (1936) 193–215.

Tugtilik (Lake Fjord) during the year spent there by Rymill, Chapman, and Riley. He had with him in Kangerdlugssuak his wife, an adopted son, and two adopted daughters. Hansi was probably the best hunter of the Sermilik country; he had with him his wife, his mother, and his brother Jacko, four children (one born during the expedition), an adopted daughter, and adopted

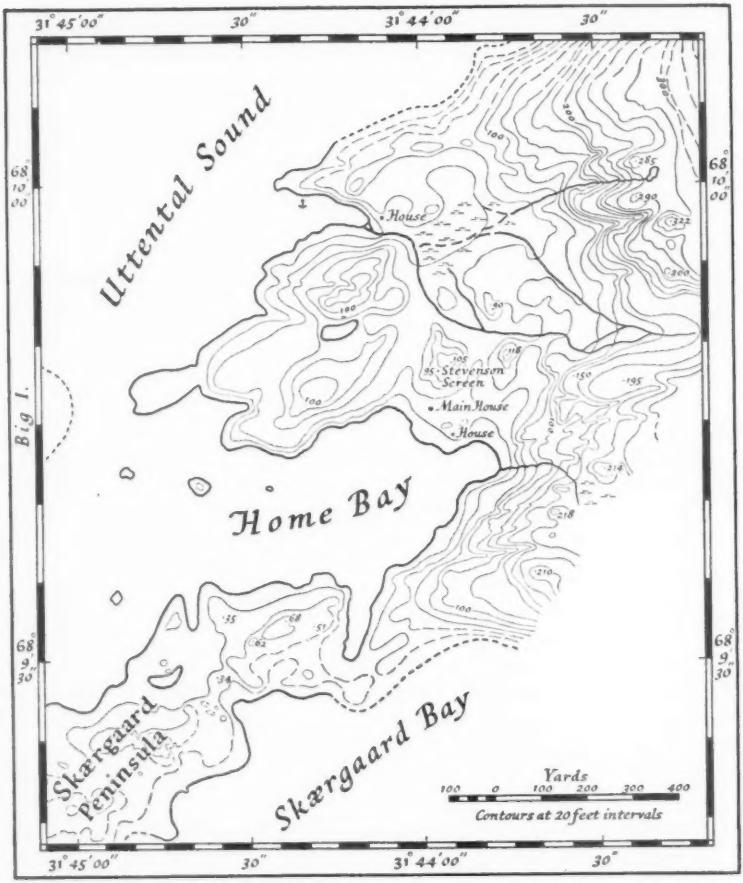


Fig. 1. Country round the Base. (*From a plane-table survey by E. C. Fountaine.*)

son. The proportion between Europeans and Eskimo proved excellent; the Eskimo hunters were able to keep us and our dogs, as well as themselves, well supplied with food, except during the lean month of February, and the Eskimo women were able to keep pace with the demand for skin clothes and boots.

While the summer journey to the Watkins Mountains was in progress, the

equipment, stores, fuel and wood for building a house had been landed under the direction of Chambers at the north end of the Skaergaard Peninsula, which lies near the mouth of Kangerdlugssuak on the east side. Captain Schjelderup had found a suitable anchorage for the *Quest*, as is indicated by the map, Fig. 1. Two wooden houses, double walled and consisting of a single room 12 × 12 feet, with a loft above, had been put up on the Skaergaard near the former Eskimo settlement by Mikkelsen's expedition in 1932. These houses and their equipment were there to encourage the Eskimo to travel up the coast from Angmagssalik, but this they had never done. They were now kindly put at our disposal by the Scoresby Sound Committee. The more northerly was occupied by the Eskimo when they gave up using their skin tents in mid-September; the other formed the sleeping quarters of Chambers, Deer, and Fountaine. Our first task on landing was to build a third house, twice the size of the others, which would provide a central mess and work-room, and sleeping quarters for the rest of the members of the expedition. This house, which had been supplied by Viggo Pedersen of Gudhjem, was put up near Mikkelsen's southern house, on what we called Home Bay. The timber was dry, and by working an eleven-hour day, sometimes helped by the Eskimo, we got the house up and most of the stores inside during the first week of September.

We were now able to begin the scientific work. H. G. Wager and his wife went off for a week to mark out quadrats, 1 square metre in area, on different types of terrain, and to record the age of all plants and seedlings within them. They had found that seedlings were abundant in many places, although the mature plants of the species were sporadic, and they wished to decide when and how the young plants died, leaving only isolated adult specimens, instead of forming a continuous mat as in temperate regions. Two geological parties, one consisting of Fountaine and Deer, and the other of Chambers and myself, made a beginning on the geology of the country near the Base (Plate 1 [1]). The mountains to the east and north-east of the Base houses are shapely peaks rising to almost 4000 feet, with glaciers among them which descend to the sea. They are composed of the plutonic rocks of the Skaergaard Intrusion, the most interesting of the three major intrusions which we wished to study. We were well situated for work on these rocks as the houses themselves were built on them, and indeed the large doorstep of the main house was an entirely new and interesting rock type.

The weather during the whole of September was almost perfect for our work. On several days a violent föhn wind could be heard roaring like a train down the main fjord where the pack-ice would be temporarily blown out. This wind was extremely local and nothing would be felt of it at the Base. In 1932, during the last week of August and the first days of September, work on Mikkelsen's expedition was stopped by a continuous downpour of rain, probably 5–10 inches. We feared that something of this sort was usual, but during the second half of August and all September 1935 there was no measurable precipitation. The nights were sufficiently cold for the Home Bay

[1] The Base houses, situated on the coast immediately below the summit of Base Peak, are too small to be seen. Base Peak lies to the south of Connecting Glacier, which offers an easy route from Kangerdlugssuak to Miki Fjord, the head of which shows on the plate.

to freeze over, and towards the end of September we were able to walk on it, though the freezing up of more open water had not begun. The middle of the day was still warm and on October 5 Chambers and I, dressed in ordinary English winter clothes, sat in comfort in the sun on the top of Base Peak, 3000 feet high.

On October 6 snow began to fall and quickly covered the rocks; the autumn period of detailed geological survey was at an end. We now turned to the task of finding a route on to the Ice Cap to be used on spring and summer journeys when we hoped to make a reconnaissance geological survey of an extensive area round Kangerdlugssuak. The route which we had followed during the journey to the Watkins Mountains provided indirect access to the Ice Cap, but owing to the steep gradients it would have been unsatisfactory for dog sledging. We had two admirable maps, one of the immediate neighbourhood of Kangerdlugssuak made by M. Spender and C. Larsen during Mikkelsen's expedition, the other of the whole mountain region between the Ice Cap and the sea, which had been made from the air survey carried out on Rasmussen's Seventh Thule Expedition. An advance copy of this map, with the air photographs from which it had been made, had very kindly been presented to us by Professor Nørlund, the head of the Danish Geodetic Institute. From the maps the general lie of a possible route could be obtained, but whether it would be a practical sledge route or even a possible way for a roped climbing party could only be decided by going there to see.

In September Fountaine and Chambers set off with 40-lb. loads on their backs to investigate the possibility of a route up the Frederiksborg Glacier. They crossed Watkins Fjord on floating brash ice only to find the going on the other side hopeless, so they returned and went some 10 miles up the east side of the Frederiksborg Glacier. They found it extremely rough and difficult and quite unsuitable as a sledge route. We knew from the summer journey to the Watkins Mountains that the larger glaciers penetrating the mountain belt provided a high road for sledge travel in their middle and upper sections. The problem of finding a route on to the Ice Cap is to find a way round the hopelessly crevassed lower 5 or 10 miles where the glaciers are falling steeply to the sea. A glacier, looking like an ordinary valley glacier from Watkins Fjord, was indicated on the air survey map as a distributary of the Frederiksborg Glacier, which would lead, with little or no fall, on to the main glacier 10 miles above its snout; this route to the Ice Cap we now determined to investigate.

Chambers, Deer, Fountaine and I started on October 16 with one week's food. We had to man-haul the sledge as the new fjord-ice was still unsafe for dogs, and the leading man had to move with caution, testing the ice with his ice spear. On the second day we reached the foot of the glacier, to which later we gave the name of Bye Glacier. The marginal moraines were not thickly enough covered with snow for the sledge, and we climbed from the fjord-ice on to the centre of the glacier where the ice cliff was lowest. After carrying the equipment in relays over the difficult crevassed portion we camped half a mile above the snout. That evening there was a prolonged roar of falling and moving ice lasting many times as long as that from a disintegrating iceberg. In the morning we found that the fjord-ice over which we

1. Country round the Base

Air photograph by H. G. Watkins, 1930

had sledged had been broken up by the falling away of a quarter of a mile of the glacier front where we had climbed on to it. This must happen seldom, perhaps two or three times a year, as the glacier is not very active. Four miles farther on, where the glacier steepened slightly, all the snow had been removed by wind. This half mile of bare polished ice we found to be present throughout the winter except immediately after a snow fall, and there was usually a down-glacier wind at this point. Such katabatic winds are a feature of mountain regions in the Arctic, but their constancy at certain favourable places was always a source of wonder to us, and frequently of discomfort also. Above this stretch the snow steadily deepened and we hauled on skis. We found that there is a fall of 500 feet on to the Frederiksborg Glacier from Bye Glacier, which is not now acting as a distributary, although it certainly did some few thousand years ago when this part of Greenland was more heavily glacierized.

Our fourth camp was on the Frederiksborg Glacier, 15 miles above its snout and above the worst crevasses, but below another ice-fall rather like that on the Sorgenfri Glacier which had given us some trouble during the summer journey. The following day we worked out a route through the ice-fall without moving camp. The shallow depressions just visible above snow-covered crevasses in summer are the result of melting. In winter, when wind-drifted snow covers the glacier there is no sign of a crevasse, unless at some point it is open. When the route here was known, we regarded it as safe for two men to pass through the ice-fall, but it was a good thing that we were a larger party when the way was being found. Above this difficulty the glacier levelled off, and we hoped that by taking a zig-zag course the crevassed parts could be avoided. We could see about 5 miles off the highest peak of the neighbourhood (8450 ft.) which my brother and I, in 1932, had called Cathedral Mountain, and to the east the two astonishingly symmetrical *aiguilles*, which we had called by the Eskimo name of Mitiwanga (breasts) (Plate 5[1]). This mountain group formed of the gneisses of the Metamorphic Complex is the finest in the whole Kangerdlugssuak region, and has a more attractive shape than the higher Watkins Mountains of Rasmussen Land. For the mountaineer they would provide difficult rock-climbing problems like those of the Chamonix Aiguilles.

We turned back on the sixth day as we had found a satisfactory route, with no very steep gradient and fairly free from crevasses, which by-passed the difficult part of the Frederiksborg Glacier. The fjord off Bye Glacier, which had broken up immediately after we had passed, was still unfrozen. We had been most fortunate in reaching Bye Glacier with a loaded sledge just after a few days of cold, calm weather when the ice would bear us. On the return we had to make two portages along rocky stretches of the coast, and then at a rocky spur we were forced to leave everything behind except our skis. After this difficulty we descended to the safe fjord-ice, and in a long day reached the Base. A month later, when ice conditions allowed us to return for the sledge, we found that it had been pulled about by bears and only a harness rope frozen into the snow had prevented it falling into the tide crack.

[1] Cathedral Mountain lies in the background on the left. The twin summits on the right are the Mitiwanga. A recent fall of snow is making the rocks unusually white.

2. *Base houses, with Brothers Peak on the left, June 1936*

Throughout November the weather was unsettled; the graph (Fig. 2) shows the rapid changes from cold to thaw which occurred. The ice of the previous winter, which at the end of August had prevented the *Quest* from sailing up the main fjord, did not disappear by summer melting, but was blown out by one of the early violent winds of winter. The föhn winds, generally succeeded by snow and bad visibility, came at about weekly intervals and prevented the freezing up of the main fjord till January. Travel was hopeless, and we began various occupations at the Base, to which we returned at intervals throughout the year. H. G. Wager worked on the physiology of arctic plants in his laboratory, which was also his bedroom. Deer and I made rock sections, microscopic examination of which enabled us to direct later field work in the most profitable direction. Fountaine, on the calmer days, began a large-scale map of the Base neighbourhood (Fig. 1), which was later used for detailed geological survey. The sixteen dogs from Angmagssalik, which had been bought from nearly as many separate owners, had to be welded into two homogeneous teams. We had also to accustom them to the single-trace method of driving, which is better for long journeys with a heavy load

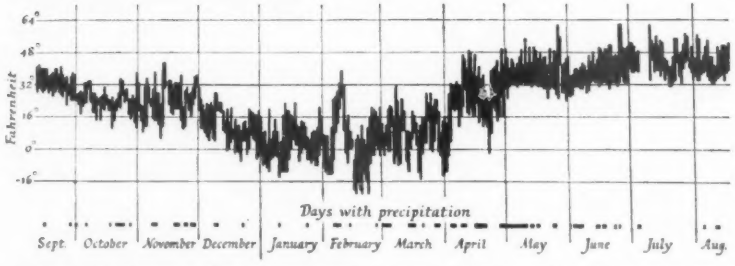


Fig. 2. Maximum and minimum temperatures at the Base from September 1935 to August 1936

than the fan method used by the Eskimo for short hunting expeditions. In deep soft snow we discovered that it was best to lengthen the trace and arrange it so that the team could run in a single track behind the leader. Bad weather reduced the hunting activities of the Eskimo, and they spent much time with us, usually arranging to be there for lunch or tea. We slowly learnt enough of the language to talk about most things, and we sought the advice of the hunters on weather conditions, dogs, and sledging. The two Eskimo girls, Augusta and Johanna, came over on occasion and helped in our houses, and Jacko helped with our dogs. Seals gradually became scarce, but occasionally bears were shot, which contributed to the meat supply. Eventually, in December, sharks had to be caught to eke out the dog food.

A cold period with little precipitation began on December 4 and lasted with one exception till the beginning of April (Fig. 2). The sun remained below the horizon from December 1 for five weeks, but the four hours' twilight round noon enabled us to make geological collections. From December 16–24 Deer and I were away in Miki Fjord, Irminger Fjord, and the mountains to the north. For one night we camped on a frozen lake, between Miki and

Irminger Fjords, which has no outlet. A strong temperature inversion took place in the still pool of air, the minimum being −35° F., while at the Base the minimum was only −2° F. We returned by the head of Watkins Fjord, where we had to travel among the jumbled blocks of ice from the Frederiksborg Glacier. Two miles took us a whole day, and it was like attempting to go along instead of across one of the bigger pressure ridges of the polar pack. Later we found that Fountaine and Chambers were attempting to cross the same part of the fjord to make measurements of the rates of movement of the glacier at its snout, but after three days they had to return, and arrived home with us on Christmas Eve. We celebrated Christmas with the Eskimo, who nowadays make much of this festivity.

Early in January Fountaine and Chambers left the Base with a team of seven dogs to make a dump of half a ton of food on the Frederiksborg Glacier ready for the longer Ice Cap journeys. They spent from three to eight days in a succession of camps, relaying daily to the next camping place loads appropriate to the gradient. This they found preferable to making a series of through journeys because it did not necessitate making and striking camp each day. A month after starting, the first load was deposited, at what they called Fork Dump, 4400 feet up on the Frederiksborg Glacier and 40 miles from the Base. Bad weather then made them lie up for four days, and they had deep snow for the rest of their work and the return. This considerable task, which took altogether six weeks, was carried out during the coldest and darkest period of the year, when it is usual for expeditions to remain in their winter quarters, but by so doing valuable time was saved for other work. While this was going on Deer and I crossed the main fjord, which had at last frozen over, and worked for ten days among the Kangerdlugssuak Intrusion of nepheline syenite.

At the end of January Deer and Hansi sledged up to the head of Kangerdlugssuak with the latter's dogs. There the huge main glacier pushes out into the fjord, producing pressure ridges and rents in the fjord-ice and exposing open water, which prevented them from reaching North Fjord. Close to South Syenite Glacier they passed the place where a party of three Norwegians had wintered in 1932–33. This had been one of the International Polar Year stations, sending weather reports back to Europe, and the Norwegian Minister of Labour had given us permission to use their house, from which we had hoped in the second summer to carry out geological investigations on the west side of the fjord. Deer found that the house, although having concrete foundations and a 5-foot wall of turf around it, had been completely demolished by the wind: an impressive demonstration of the strength of the föhn blowing from the Ice Cap down this narrow funnel-shaped fjord. Short journeys were also made at this time by H. G. Wager and his wife into the main fjord by way of the Sound and Watkins Fjord to see the conditions of the vegetation and the extent to which it was uncovered by snow as a result of the violent winds. Another four-days' journey for geology was made to Nameless Valley and the outer coast by my wife and me. Travel in the cold but, on the whole, storm-free period of midwinter was satisfactory, while in the variable weather of late autumn it had proved impossible.

Spring journeys

On February 9, after two days of snow the temperature rose to 39° F., and for an hour rain fell, producing a layer of ice ¼-inch thick on the top of powdery snow. A week later there was the coldest weather experienced at the Base, with minima on several days between −20° and −22° F. The rain was the more remarkable because it occurred in the middle of a long period from December 1 to April 3, when, except on this occasion, the maximum temperature was continuously, and usually far, below freezing (see Fig. 2). Fountaine's and Chambers' dogs, returning from the dumping journey after this thaw, had their legs shaved from foot to knee joint, and also developed bleeding sores, the effects of breaking through the glassy ice surface. It proved to be a month before they could be used again. The bitches, which have thicker hair, were less affected, and we discovered that this was the reason why Hansi had a team consisting of five bitches and two dogs, which at first we had thought rather remarkable. He was able to make short journeys with his team, but for us sledging was impossible, as we could not devise any suitable canvas dog shoes. Deer and I were again reduced to man-hauling a sledge for a journey across the main fjord to examine the rocks on the north side of Hutchinson Glacier. Although the crust was slowly thinning by sublimation, especially where the dry föhn blew hardest down the centre of the fjord, this trip convinced us that it would be two or three weeks more before the projected journey for 100 miles along the sea-ice to the Lilleoise Mountains would be practicable. It was decided therefore to give this up and to start at once on the first spring journey on to the Ice Cap, as above 1000 feet no thaw crust had formed.

Fountaine and I set off with one dog team on March 5. Chambers was to have come, but a frost-bitten toe from the dumping journey had by no means recovered. Our start was a month earlier than originally planned, and we feared bad weather, like that experienced at this time of year during two spring journeys of the British Arctic Air Route Expedition. The sledge used was a type designed by Visting, which we found to have many advantages over the earlier Nansen pattern. On the larger valley glaciers we adopted the plan of having one man ahead on a 60-foot line with loops at intervals to assist him in getting out of crevasses should he suddenly disappear. The line was threaded through the centre dog-trace, and the leading man, wearing a harness, carried out the functions of finding the route, making a track for the dogs, and when necessary pulling as well. Except for an occasional half mile, we used Eskimo skis, which are a foot shorter and a little broader than ordinary skis, with permanently attached seal skins and a simple loop of seal skin as a binding under which moccasined feet slide easily. From Fork Dump on the Frederiksborg Glacier we had to take on a load of 670 lb., an allowance of 1 lb. of pemmican per dog per day, and a man ration of 1 lb. 10 oz. The first eight days from the dump were up what we named Windless Glacier, because at four different times of the year no signs of strong wind were found here. Each day we had to relay the loads. The sledge, which had broad metal-covered runners, slid fairly well after a slight new snowfall, but on a wind-distributed snow surface with temperature between 0° and −30° F. both it and our skis met with extreme resistance. During seven days the

Fig. 3. Kangerdlugssuak. (Redrawn by permission from the maps of the Danish Geodetic Institute. New names are those proposed by the author.)

distance travelled was only 18 miles and the height gained about 1500 feet; it was obvious that we should have to alter our plans if any geological work was to be accomplished. We therefore made a second dump on the Eastern Frederiksborg Glacier, and with a lightened sledge carrying only 10 days' food made a journey among the Prince of Wales Mountains, named by Lindsay who saw them in 1933 from the Ice Cap side. We found here the basalt resting on the gneisses with no intervening sediment and also an upper series of basalts distinct from those elsewhere.

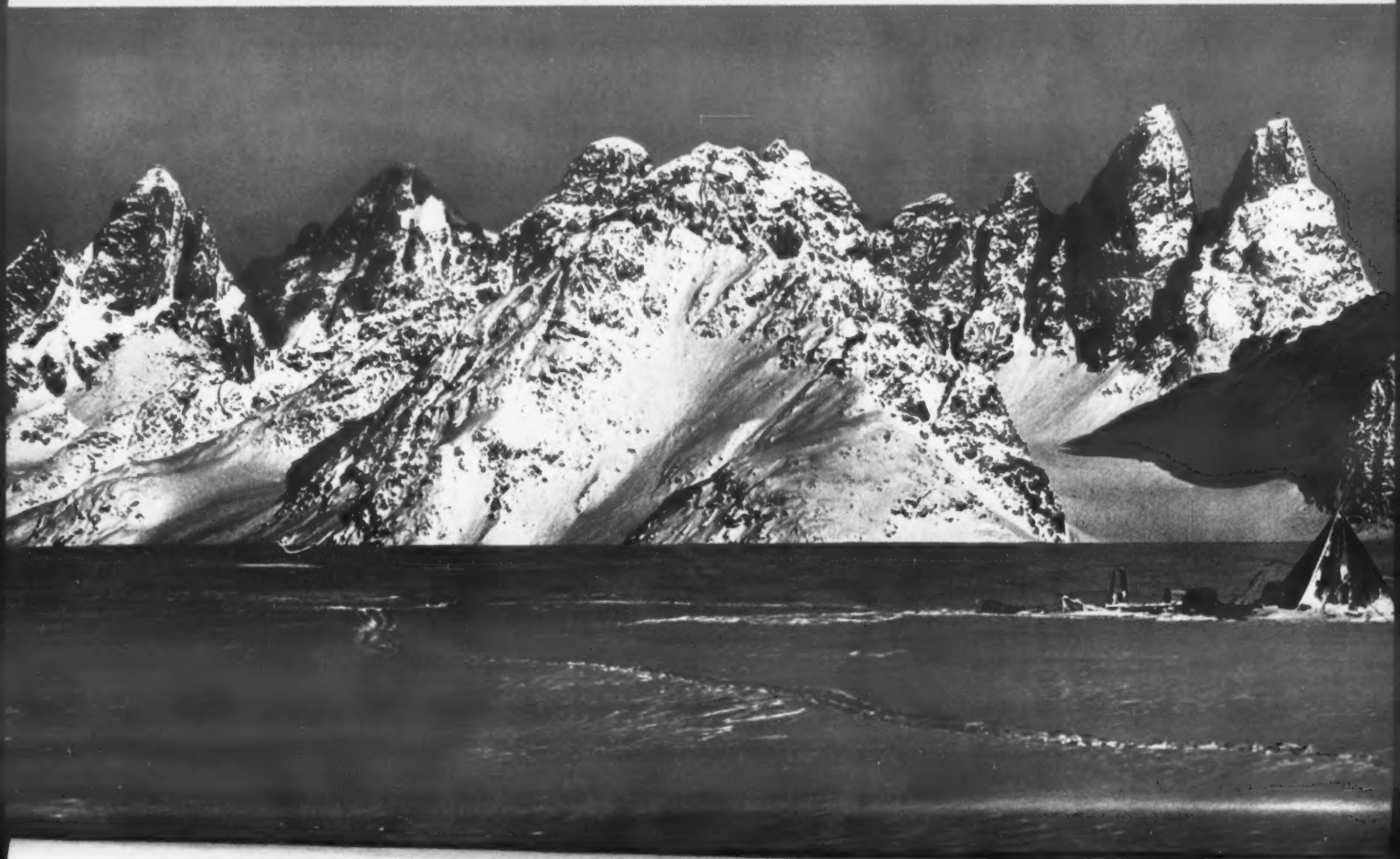
After picking up another ten days' food from the advanced dump we set out again in thick mist and falling snow. One man ahead with a compass tried keeping our direction in various ways, but there was not enough wind blowing or sastrugi on the surface of the snow to give him any help in keeping a constant course. In the end we put the compass on the front of the sledge away from the iron dog-pemmican tins and encouraged Pinitsok, the leading bitch, to make the course herself. After a time she settled down to keeping a constant direction, and for as much as three quarters of an hour she would not require correcting; how she did it we could not tell. That evening the snow cleared and there was 85° F. of frost, the lowest temperature we recorded during the year. Passing down between the Seward and Lindbergh nunataks, we reached the head of Christian IV Glacier, and then turned up Gronau Glacier on to an outlier of the Ice Cap which we called Seward Plateau.

Back at the advanced dump ten days later, we decided to leave the remaining ten days' food and return to the Base with the load of rocks we had collected. Weather conditions had been good on the whole, and by making two separate journeys from the advanced dump we had covered 360 miles in five weeks. The conditions among the mountains and on the small plateau cut off from the main Ice Cap by a shallow depression were very different from those experienced during the two March–April journeys of the British Arctic Air Route Expedition which were on the main Ice Cap itself. Then the föhn wind was far more violent, probably because it was draining from a much greater area of Ice Cap. Only once, near the head of the large Christian IV Glacier, did we have a comparable wind, and this was as bad as any on the previous expedition. For the most part the snow surface was correspondingly different, being wind drifted but not strongly compacted. On hard sastrugi we found that the sledge did not slip easily, but it did not sink in; on soft new snow, which usually occurred with a higher temperature, the sledge sank in but at the same time slid easily; intermediate conditions which we had most of the time were worse, for the sledge sank jerkily with groans and was very difficult to move on the compressible grit-like surface.

The second spring journey, made by Chambers, Deer, and H. G. Wager, began during the last cold spell of the winter on April 25. With one sledge, one pyramid tent for the three of them, and food for twenty-one days, they crossed the main fjord and worked up into the mountains to the west by means of South Syenite Glacier. This glacier usually provided an easy route as it climbs 2000 feet in 10 miles at an even gradient. Hard crust alternating with soft snow however continually overturned the sledge, and for four days they were compelled to relay. When they reached the north side of the

3. Middle Frederiksborg Glacier with gneiss mountains, April 1936

4. Upper Frederiksborg Glacier with basalt mountains, March 1936



Hutchinson Glacier, they dumped rather more than half their food to be used later for the journey down the coastal mountains. With six days' food the party crossed the Hutchinson Glacier and for three days worked on the geology of the Cape Edward Holm Intrusion. The weather then broke; for the rest of the time they had almost continuous snow and mist, and no geological work could be done. The lower glaciers proved to be no place for travel by compass in thick mist, for it was not long before a hopelessly crevassed area was encountered, and the party had to camp and wait for better visibility. After going only a few miles in two days a dump of the rocks collected was made to lighten the sledge, and this had to be fetched later in the year. During the early part of the bad weather the snow had a brownish tinge. They all noticed it, though no one ventured to make any comment, thinking it a subjective effect. Subsequently they found that day's snow as a brown layer when digging to pitch the tent. There were no winds at Kangerdlugssuak which might have blown dust into the air. It is probable that the dust was picked up from the Icelandic lava deserts, and carried by a high-level wind over Greenland.

Having spent nine days on their six days' rations, and believing that they were across the Hutchinson Glacier, they camped to await better visibility. Next morning it cleared for a moment, and they saw only a quarter of a mile away the ridge at the foot of which the food dump lay, but the snow had obliterated the land marks on the ridge by which its position was fixed. They probed with ski sticks where they thought the boxes were, but failed even to reach the hard snow surface on which they had laid them. There had been 8–10 feet of new snow, and after four hours they gave up the search, though the loss meant real hunger for men and dogs. (At the end of their summer journey Fountaine and Deer found this dump, which was then only just showing above the snow. The old ski tracks were still visible, as was the area they had quartered during the search; they had only failed to locate the dump by 2 yards.) The party now pushed on for two days in mist and snow, covering only 6 miles. On the next morning the dogs, who had only had half a pound of pemmican during the last eight days, refused to pull to an appreciable extent, and man-hauling without the dogs' help was not feasible in the deep snow. So the dogs, tent, etc., were left, and the three men set off on skis for a food dump put down 10 miles off at the foot of South Syenite Glacier during the previous summer. They reached the dump after twelve hours. Each man ate what he fancied, but was surprised at the smallness of his appetite, and after resting for a few hours they struggled back with food to the dogs. The weather now improved slightly and they got the sledge and dogs down the glacier to the dump in two short days. From here, on the sea-ice, the dogs were able to pull more effectively, and the party reached home on May 13.

The actual fall of snow at the level of travel was difficult to estimate, but it was certainly 15 feet and perhaps 20 feet. During the bad weather the temperature remained between 28° and 32° F., but it was never actually thawing for more than half an hour at a time. The leading man formed a track with his skis 2 feet deep in the clogging snow, and when any one stepped off his skis he sank up to his waist. The party was continuously wet for about a week and developed a peculiar type of mild frost bite in fingers and toes

5. *Cathedral Mountain group, April 1936*

which was troublesome for a fortnight after the return. The remarkable spell of precipitation went on till May 20; at the Base the snowfall was equivalent to $6\frac{1}{2}$ inches of water, but it largely melted as it came.

The more important geological work of the expedition lay within about 40 miles of the Base and was done on short journeys up to ten days in length. On longer expeditions our geological collections became unmanageably heavy, and more than once part of them had to be dumped to be fetched on some other occasion. The surveyor has this one great advantage over the geologist: that his sledge gets lighter daily by the man and dog food consumed. Our sledges became heavier daily by 20 or 30 lb., and not many days of such sledging are possible before a team of seven dogs is pulling its maximum load of 700 lb. For short journeys, we watched the weather closely, as it was often possible to choose a period after a storm when the surface was hard and another snowfall unlikely for some days. Weather observations such as are kept by the smaller meteorological stations in England were taken at the Base three times daily, generally by Mrs. H. G. Wager or my wife. We became fair judges of when snow would fall, and we knew what the effects would be of the föhn which periodically swept down the main fjord and valley glaciers, but we could never tell when it would blow.

In early March Deer and Hansi, with the latter's dogs, spent ten days among the mountains at the head of Amdrup Fjord, approaching them by way of South Syenite Glacier. Even if there was little chance of hunting, Hansi was very willing to make such journeys, partly because he liked to see the country and partly because he was interested in our technique of travel. Deer had at times some difficulty in persuading Hansi that the route was safe, as the Eskimo have not developed any method of dealing with hidden crevasses and are naturally sceptical of ours. On the whole we found it best to ask the Greenlanders to accompany us on coastal journeys. Towards the end of March Deer and H. G. Wager investigated the mountains inland from Cape Deichmann, which form part of the Cape Edward Holm Intrusion. The dog team, which had been badly cut by the ice surface during the return from the dump journey, was by then fit enough to be used for a short trip of a week. At the end of April, just before the break in the cold weather, Fountaine and I carried out geological work from the sea-ice at the head of Amdrup Fjord. This fjord has never been found accessible by boat in the summer because of the numerous producing glaciers and the absence of down-fjord winds.

When the weather improved after the continuous snow of the first half of May, Fountaine, Jacko, Hansi, and I set off for the head of Kangerdlugssuak. Fountaine wished to measure the rate of movement of the Kangerdlugssuak Glacier, probably the fastest on the east coast of Greenland. He and Jacko also intended to live for five days entirely on meat in preparation for a medical experiment which Dr. Hemsworth, of University College Hospital, had suggested. The diet of the Eskimo was formerly entirely meat and blubber, and the experiment aimed at comparing the effect of such a diet on Eskimo and on Europeans who were not used to it. Hansi took his sledge, which was of the usual Eskimo pattern, but with detachable broad runners covered in tin, a thoroughly satisfactory device which he had invented. On

this occasion in late spring we should not have cared to venture over much of the rotting and difficult ice in the main fjord without Hansi's knowledge. Five miles short of the mass of icebergs coming from the Kangerdlugssuak Glacier the fjord-ice had been pushed into undulations; the hollows were full of water and the ice at the bottom melting fast. Great rents up to 50 yards across formed a network and were only bridged here and there. In this awkward region we came across bear tracks, and at a special word of command from Hansi his dogs suddenly doubled what had been quite a fast pace. Hansi and the dogs worked out together an intricate route with a perfect understanding between them, and we were given a splendid demonstration of dog-driving by one of the best Eskimo in East Greenland.

The condition of the Kangerdlugssuak Glacier was very different in 1936 from what it was in 1930. Then a floating ice tongue 5 miles long pushed out into the fjord, where it periodically gave rise to large tabular icebergs a quarter of a square mile in area (Plate 6). In 1936 the continuous floating tongue had been replaced by a jumble of smaller bergs and brash ice (Plate 7). This was more extensive than the tongue, and shut us off from North Fjord so that this part has not yet been visited. The floating tongue whose rate of movement Fountaine wished to measure did not exist, but in any case we had to hurry back, as seals, which we expected to find, were completely absent, and we were not lucky enough to get a bear. On this trip we found the food dump put down by Watkins in 1930. I well remember that some of the stones which covered the boxes had required the two largest Norwegian sailors to move them. The rocks were now widely distributed, and most of the boxes seemed to have disappeared, but drifts of snow may have been hiding some of them. Bears had opened two or three tins of margarine and pemmican with their teeth or claws, and I thought they must have been responsible for the destruction of the dump. Hansi however explained that it had been broken open and distributed by a huge wave produced during the formation of an iceberg from the Kangerdlugssuak Glacier, and it seemed to me he was probably right.

The second summer

At the end of March a wide lead of open water formed off Cape Hammer and stretched towards Cape Edward Holm. Here the Eskimo went for seal hunting when they were not making long sledge journeys in search of bears. About this time pools of open water formed among the Skaergaard Islands where the currents were strongest (Plate 8), and in April these became suddenly inhabited by a large number of eider ducks and black guillemots. The fjord seals came up through holes in the ice and basked in the sun in April and were very abundant on the ice in May and June. The first flower of the year, the purple saxifrage (*S. oppositifolia*), was found on May 4, and by the end of the month the crowberry, the two dwarf willows, the moss campion (*Silene acaulis*), the alpine saxifrage (*S. nivalis*) and *Minuartia biflora* had been found. During a violent wind on the night of May 27–28 the ice of the main fjord suddenly blew out to a line joining Amdrupneset and the south-west corner of Kraemers Island (Plate 9). This wind was one of the most typical föhns we experienced, producing a marked peak on the temperature

graph for that date (Fig. 2). On June 22 we launched the whale-boat, which had been left for the winter on one of the outer islands where the summer break up of the ice would first take place, and on the same day the Eskimo ran their umiak over the still thick bay-ice into the open water. With the help of a tow from the whale-boat, which was fitted with a Penta outboard motor, they crossed to the south-west corner of Kraemers Island and established a hunting camp. Here they stayed for six weeks except for visits to the Base, mostly at week-ends, when, as was their custom, they all came to tea with us. Their camp was ideally situated for narwhal hunting, and when we visited it about an acre of ground was covered by drying meat which was later taken back to Angmagssalik for use in the following winter.

On June 23, Chambers, my wife, and I went by boat to the western peninsula of Kraemers Island and carried out a detailed geological survey. From here we had a good view up the fjord and saw that all the ice had blown out; this happened three months earlier than in 1935. It was now possible to begin the summer programme of geological work on the west side of the fjord. A few days later the same party with six dogs, a sledge, and food for five weeks, set off from the Base in the two whale-boats. Chambers wished to make collections of birds and insects, and my wife undertook the botanical collecting. Where the floating ice was thinly scattered we travelled luxuriously, using the outboard engines. At other times it was a matter of pushing and hauling the boats through thick brash and sometimes our rate of progress was only a mile in three hours; if it was slower than this we gave it up and camped. We spent five days at the foot of South Syenite Glacier, five days in the corrie south of Notch Mountain, and two days in Cartographer Cove. The ice conditions would not let us penetrate farther towards the head of the fjord. On most days there was a violent wind down the fjord lasting from about midnight until midday. The upper part of Kangerdlugssuak is apparently liable to föhn throughout the year, and in the frequency and violence of the winds must be comparable with Scott's Base in the Antarctic in 1910–12. A vast amount of ice was blown out daily, but the Kangerdlugssuak Glacier seemed to produce an unlimited supply. Plants grew more luxuriantly here than round the Base, probably because much of the ground became snow-free early in the year as a result of the strong winds. The most beautiful plants were the abundant dwarf rhododendron and the saffron yellow Iceland poppy which here grew down to sea-level. When near the coast Chambers was able to keep the pot well supplied with ptarmigan, eider duck, and guillemots.

On July 6 we left the coast with a fortnight's food and sledged up South Syenite Glacier in order to investigate the centre and north part of the Kangerdlugssuak Intrusion. Here the glaciers are almost level and little crevassed. Nevertheless on one occasion our three leading dogs fell through and the three of us were quite unable to pull them back. We discovered that in soft summer snow the best way of getting them out was to break a steep groove through the edge of the crevasses up which the dogs, with the help of a pull from above, were able to scramble. At South Syenite Glacier Nunataks on July 14, as arranged, we met Fountaine and Deer, who had just completed their Ice Cap journey round the head of Kangerdlugssuak. They had

travelled 450 miles in six weeks and had been living on a ration of 1¾ lb. per day per man and 1 lb. of pemmican per dog, but both they and their dogs had not lost condition in any way.

Fountaine has written the following account of the Ice Cap journey :

"Deer and I set out on the second long inland journey on June 1. We intended to reach the Ice Cap via the Upper Frederiksborg Glacier, travel along the north edge of the Kangerdlugssuak Basin to the mountains on the west of the fjord, and then turn down to the coast by the Hutchinson Glacier. When we left the Base the fjord-ice was beginning to rot, and having travelled successfully over it for 12 miles and reached within 200 yards of the shore at Bye Glacier, the ice broke beneath the sledge and we found ourselves up to our necks in icy cold water. Fortunately only the back of the sledge had broken through, the dogs and the front remaining on firmer ice; after some difficulty we ourselves were able to get out on to the ice and eventually picked our way delicately to the shore, where we camped and dried our clothes and equipment in the sun.

"Windless Glacier, where L. R. Wager and I had met with such a back-breaking surface in March, now went more easily in spite of the presence of a foot of new snow. Before reaching the small dump which had been left in April on the Eastern Frederiksborg Glacier, we climbed the southernmost of the Triple Nunataks and found some fossil plants which had been well baked by an old volcano. On this glacier, at a height of only 5000 feet, we had the minimum temperature for the trip, −15° F., which seemed rather low for the time of year. We reached the small ice cap of Seward Plateau and took aneroid readings at half-hour intervals in order to determine the detailed form of the surface, and then turned west towards the Kangerdlugssuak Basin. As we approached a group of three nunataks, which we called Lindsay Nunataks, Deer suddenly pointed out an ivory gull; it was the first noticed that year and recalled the three ivory gulls seen on the day following the successful attempt on the highest peak of the Watkins Mountains during the previous summer.

"We climbed the most northerly of the Lindsay Nunataks in a howling blizzard and found a broken ice-axe which Lindsay had left there on his journey across the Ice Cap in 1934. Owing to the blizzard we did not observe anything other than the axe, and not until we returned to England did we learn that it marked the position of a note which he had left for the next travellers. For the next twenty days of the journey across the upper part of the Kangerdlugssuak Glacier we had continual high wind and drift. After crossing the basin we reached the Triangular Nunataks (so called from their configuration on the map) and then made a detour to the east down to Gardiner Lake, where we found fine crystals of magnetic iron ore. From here we had a splendid view of the immense Kangerdlugssuak Glacier coming straight down from the Ice Cap to the sea. This district, although only a few miles from the head of the fjord, would be difficult or impossible to reach from that direction because of the very crevassed glaciers. After returning to the Ice Cap and crossing Hutchinson Plateau, where we again took frequent aneroid readings, we pitched our final camp on the Ice Cap on the last day of June. Next morning,

which was the first really pleasant day we had had, we climbed Panorama Nunatak, and enjoyed a superb view of the coastal mountains from what we believed was Mount Forel in the south to the Watkins Mountains 100 miles away to the north-east.

"As we had made unexpectedly good progress in spite of high winds and rather bad weather, we had fourteen days' food in hand, and Deer suggested making a detour to the south in order to complete the geological work that had been abandoned in May because of the heavy snowfall. The route was complicated by several ice-falls and huge crevasses often over 100 feet wide, but on July 11 we had reached a small food dump left for us by the geological party working in the neighbourhood. We had travelled by night, partly for the sake of the dogs, who pulled better when the sun was low and the air cold than in the glare and heat of the day, and partly because the bridges across crevasses were safer.

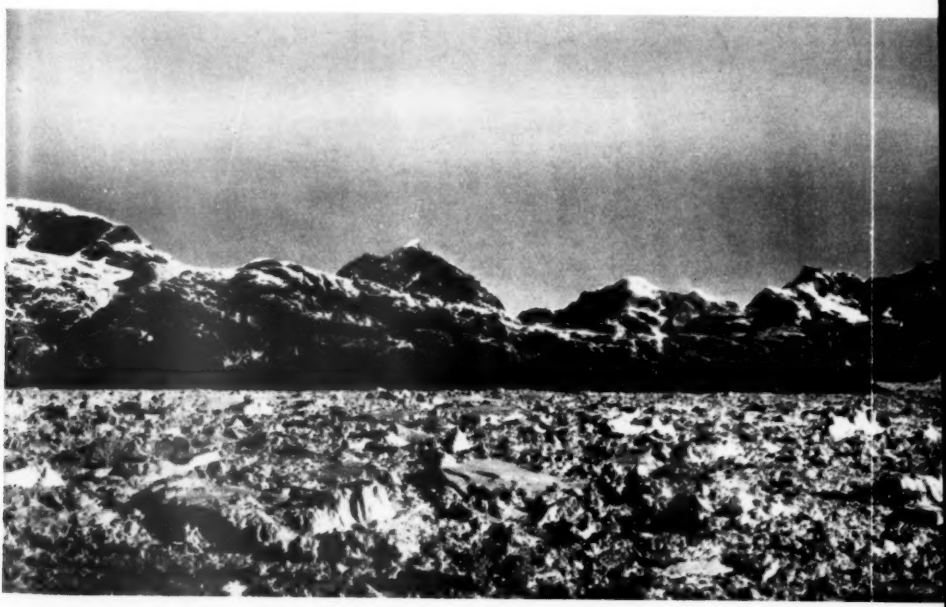
"The weather and surface conditions during this journey are worth comparing with those experienced by Lindsay in 1934, and by J. M. Scott's party in 1931 when crossing to Ivigtut. A thaw-crust surface persisted to Fork Dump and then was not encountered until we descended to a height of 5000 feet on Gardiner Lake Plateau, and then later when we were below 6000 feet on the glaciers to the south of Hutchinson Glacier. Lindsay in August had sledged across the Kangerdlugssuak Basin on thaw-crust, and most of Scott's crossing in July 1931 was on a similar surface at heights of 7000 and 8000 feet. We had fifteen days of snow during the six weeks, and the general conditions were similar in this respect to those which prevented Lindsay from accomplishing as much survey as he had intended. The winds experienced while travelling along the edge of the Ice Cap were stronger than we had expected, and for a period of three weeks we never estimated its force at less than 4, while the average was between 5 and 6. The wind direction changed as we crossed the Kangerdlugssuak Basin, being persistently from the north on the north-eastern side and gradually swinging round to north-west as we crossed to the south-western side of the basin. This immense depression in the Ice Cap, where it drains into Kangerdlugssuak, acts as a wind-channel and gives rise to the violent föhn winds which are such a characteristic feature of the main fjord weather."

From the camp at South Syenite Glacier Nunataks, Chambers and Fountaine returned to Base. Chambers joined H. G. Wager and Mrs. H. G. Wager for the last inland journey, and Fountaine continued mapping the immediate surroundings of the Base and carried out the remaining medical experiments. Deer replaced Chambers, and with my wife and I continued work on the Kangerdlugssuak Intrusion for another week. Then after a short return to the Base the same party made a whale-boat journey to finish the geology of the Cape Edward Holm Intrusion. On one long day we also made a brief visit by boat to Nordre Aputitek and Flat Island.

The last inland journey to the middle region of Christian IV Glacier was made for botanical purposes and is best described in H. G. Wager's own words.

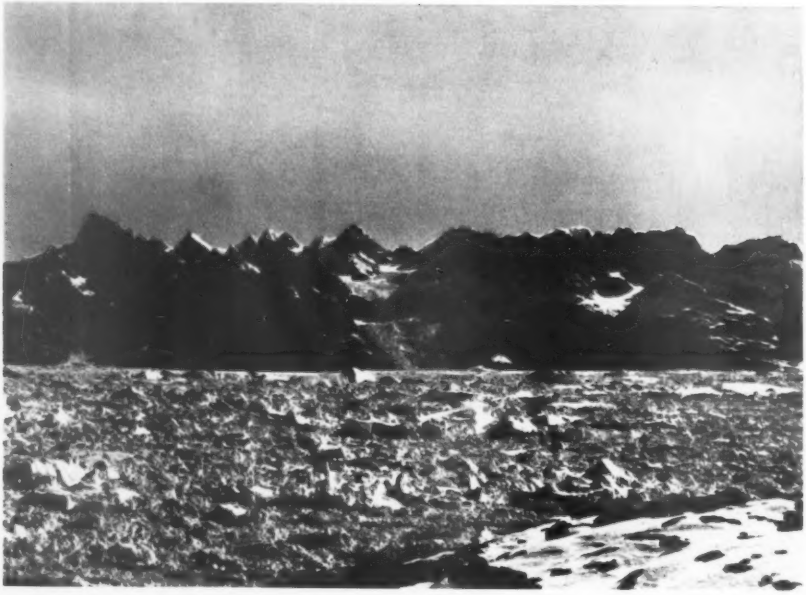
"In the beginning of April my wife and I made a dump of food above the difficult and crevassed lower section of one of the glaciers falling into the head

6. Floating tongue of Kangerdlugssuak



7. Bergs and brash ice replacing the ice

gssuak Glacier, August 1930



the ice tongue, May 1936

8. First open water, April 1936

9. Break up of fjord-ice by the föhn, May 1936

10. Crevasse on the edge of the Ice Cap, June 1936

of Watkins Fjord. A sledge and eighteen days' food for men and dogs were put down. This was in preparation for a summer journey because later the approach would be over bare rocks and scree. On July 21 the same party, with the addition of Chambers, left the Base with tents, ropes, etc., and four dogs on chains, to walk to the food dump by way of Miki Fjord. By the time the dump was reached the dogs' feet were somewhat cut by the journey over scree and dry glacier. After the first few miles of sledging over continuous dry glacier their feet became so sore that they could not pull, and it was difficult even to make them walk. For the rest of the trip there was trouble from this cause, although dog shoes were improvised from all possible spare clothing. Except for three and a half days on Christian IV Glacier, when the dogs did their share of the work, the sledge had to be man-hauled. The glaciers were dry up to about 4000 feet, and even above this the snow was hard and prevented the dogs' feet healing up.

"The party travelled up to Black Cap from the Base in four days, and from there made thorough collections on Sedimentary Ridge. Flies, spiders, moths, and a large collection of plants were obtained. In the afternoon of the same day a preliminary exploration of the Sorgenfri Glacier Icefall was made, but it appeared to be impossible, and this was confirmed next morning by climbing a neighbouring small hill. Although the party was nearly three weeks earlier than that which climbed the Watkins Mountains in 1935, the glaciers were already much drier and the Sorgenfri Icefall was just at the level where crevasses were appearing as the snow melted. Above the Icefall the glacier could be seen for another 10 miles to be heavily crevassed, although in the previous year no open crevasses were met with there.

"We had proposed to collect from the nunataks at the head of the Sorgenfri Glacier, but this had to be given up, and instead we decided to try and cross on to Christian IV Glacier via Windy Gap, where we hoped to find better travelling conditions. This glacier was reached on the ninth day from the Base, but it too was heavily crevassed. The crevasses were very uniform in direction and spacing: they were several miles long, running slightly upwards to the centre of the glacier and occurred every 20–40 yards. For 20 miles the party sledged through this awkward country and then found slightly better going up the edge of the glacier. Trouble was also experienced from lakes which had to be circumvented, and from water courses which were forded where not too swift.

"On the twelfth day from the Base the party had reached a position a little more inland than the farthest inland camp of the previous summer, but on the opposite side of the glacier. Collections of plants and insects were made at intervals of about 10 miles on the rock outcrops bordering the glacier, and in two places the altitude zonation of the plants was studied. On the return journey more fossil plants were collected from Coal Corner. The sledge was discarded when the party had to leave the glaciers, and all essential gear and the collections were carried back to Miki Fjord whence they were taken to the Base by boat."

The Eskimo

When Gustav Holm first reached Angmagssalik in 1883 he heard a story from an old man whose father claimed to have reached the southernmost

settlements of Kangerdlugssuak. This man had not seen any one at Kangerdlugssuak, but while he slept he had been stabbed in the leg and was so frightened that he had hastened back to his own people. If this story is true it would mean that Eskimo were still living at Kangerdlugssuak about 130 years ago. Mr. H. Larsen, who carried out archaeological work at Courtauld's invitation in the summer of 1935, considers that the state of preservation of the houses and graves at Kangerdlugssuak is such as not to conflict with the idea that they were in use till a hundred or so years ago. It is clear from the archaeological evidence that the Eskimo living in Kangerdlugssuak reached a high state of culture, but later dwindled in numbers and eventually died out. The name Kangerdlugssuak meaning literally "large fjord," and the traditional knowledge about the place have persisted among the Angmagssalik Eskimo to the present day; they have thought of it as a paradise swarming with seals, bears, and narwhals. Through the kind offices of Captain Ejnar Mikkelsen, who has done so much for the East Greenlanders, the Danish Administration gave us permission and facilities to take two families from Angmagssalik to Kangerdlugssuak for the year we were to spend there. Enoch, the older of the two Eskimo hunters who accompanied us, was one of those who in 1928 had worked up the coast with his wife and family as far as Nualik, which lies only 80 miles south of Kangerdlugssuak. Further progress in their umiaks, which are the only means that the Eskimo have of transporting their families and possessions, had been prevented by difficult ice. During the winter they spent at Nualik, Enoch and three others had sledged as far north as Cape Edward Holm, and there had a glimpse of the mouth of Kangerdlugssuak. This is the most enterprising journey made by East Greenlanders since 1883, when they first became known to Europeans, and it was particularly satisfactory that we were able to take this fine hunter to the fjord which he had tried with such courage to reach.

The Eskimo formed an essential part of the expedition. Without them it would have been necessary to take several other men to hunt, and we should not then have had the help in other directions which the Eskimo gave us, nor the constant interest which they provided. When they first saw Kangerdlugssuak and in particular the Skaergaard where they were to winter, they were disappointed because the place was so bleak and without vegetation. Nevertheless by September they had discovered various places where crowberries flourish, such as the south-facing slopes of Connecting Glacier, and the women, accompanied by Mrs. L. R. Wager, made umiak expeditions to collect large supplies. The good hunting soon impressed the men. In 1935–36 we never saw the shoals of saddleback seals, fifty at a time, which were frequently seen during Mikkelsen's Expedition in 1932; nevertheless there was plenty of game. Four of the Eskimo had kayaks, but only Enoch and Hansi were skilled hunters, though Jacko became one during the course of the year. When possible, they provided meat for us and our dogs, and, with the help of caches made when there was an abundance, we were never seriously short. In exchange we provided them with a certain amount of biscuit, rice, sugar, and tea. It seemed a little unsatisfactory that they should regard these foods as essential, but we were dealing with two of the richer families who, even at Angmagssalik, now buy a good deal of starchy

foods. Seal-hunting was carried out in the main fjord off the Skaergaard Peninsula and in Miki Fjord. Bears were obtained at various isolated places up to 30 miles from home. Hansi and Enoch sometimes went off bear hunting for one or two nights, but more often they would make long one-day sledge journeys of 40 or 50 miles. The younger hunters got several bears which came round the Base. Some of the females had small embryos which very much interested the Eskimo, as this stage is never found at Angmagssalik. Narwhals were obtained most frequently just inside the mouth of the main fjord and in the Sound. Although they make most money from selling bear skins, the narwhal hunting gave them most satisfaction; before this year only Enoch had ever killed narwhals. Narwhals are now rare in the Angmagssalik district, and yet they are of vital importance for their ivory, which is an essential part of harpoons and valuable for very many other purposes. It is no easy matter to hunt successfully a large narwhal weighing about a ton, and two or three men have to collaborate. Towards the end of the second summer they had so much meat that they only hunted the male narwhal, and having killed it took only the ivory tusk. They had in all about twenty tusks to take back to Angmagssalik and this should provide a valuable and much-needed increase in the total amount of ivory possessed by the tribe.[1]

In the winter the Eskimo women never stirred more than 100 yards from their house except during the excitement of a bear hunt or to visit us. About a third of their time was spent preparing skins and sinew and cutting up the meat, the rest being occupied sewing for themselves and us. Mrs. H. G. Wager and Mrs. L. R. Wager had most to do with the Eskimo, and they would often spend one or two hours daily in their house. They learnt their methods of sewing and embroidery and saw or heard about most of the aspects of their lives. The attractive and amusing children were a great help in learning the language, and Paula, the grandmother, was a source of information about the times before European influence had been felt. The habits of the Eskimo are undoubtedly changing, but the conditions of life are such that really radical changes would mean extinction. The admirable policy of the Danish Administration in controlling the rate and direction of change by maintaining a monopoly is undoubtedly for the best.

Return

As early as the end of June the pack-ice in Denmark Strait appeared thinner and more navigable than at any time during the previous summer, and on July 22 the keen eyes of the Eskimo detected three sealing ships fishing only 10 or 15 miles out to sea. Arrangements had been made through Dr. Hoel of Oslo for a sealing vessel to fetch us, if ice permitted, between August 15 and 25. If bad ice prevented this, reasonable attempts were to be made later, but should these fail we were to be left until the following year. We

[1] Hansi kept a careful list of the game killed each month. The totals for the year were: 410 seals (including 22 bearded seals), 28 bears, and 40 narwhals. December to mid-April was a lean time, and in February no game was killed. The Kangerdlugssuak region will be of great value when pressure of population forces the Angmagssalik Eskimo to find new hunting grounds. On the evidence of the hunting in 1935–36 Captain Mikkelsen is already planning to establish an Eskimo colony there.

had taken food and fuel to make a second year possible, and indeed with the help of the Eskimo it should have been reasonably comfortable, so that I had made it clear before Courtauld left in 1935 that we did not wish any expensive or dangerous attempts to be made to fetch us away. We had no wireless apparatus, apart from a time-signal wireless set on which we occasionally heard scraps of news. This was a definite policy; it would have involved much extra work and have been costly to have had reliable wireless communication. Our main reason however for not including it in our equipment was that the expedition would be a self-contained unit not needing any help from outside, and indeed not being able to get it during ten months of the year. Wireless communication would have been helpful during the second summer, if our relief ship had not been able to get through. But it turned out that the ice conditions were so favourable on the east coast in the summer of 1936 that, on July 29, a fortnight earlier than we expected, we found, on returning from one of our whale-boat journeys, the s.s. *Selis* at anchor off the Base. We were welcomed in a most friendly way by Captain I. Johannesen and the crew. The *Selis* had already relieved the Norwegian station of Torgilsbu on the south-east coast of Greenland and had done some successful hunting on the way north. As there was still work to finish off, and three of us were still inland on Christian IV Glacier, the Captain agreed to fish sharks on the Kangerdlugssuak Banks until August 17, and then return to fetch us. Three more short whale-boat journeys were made, and then the collections were packed. At 10 a.m. on August 19, we and the Eskimo went aboard the ship and Kangerdlugssuak was left uninhabited once more.

There was as little ice as in the favourable years round 1932, and we reached Tasiusak, the main settlement of the Angmagssalik District, in two days; the reverse journey during the previous summer had taken us twenty days. During the year there had been a very serious influenza epidemic at Angmagssalik which had killed seventy out of the total population of eight hundred. They had feared that we might have had the disease too, but apparently we had left before it was imported. We found satisfactory homes for our dogs, carried out our other business and left at once. It was extremely sad to say goodbye to our Eskimo whom we had come to know so well and who had contributed so much to the success of the expedition.

In the Denmark Strait the *Selis* was caught by one of the bad storms which swept the North Atlantic that summer, and we were hove to for some time where icebergs were numerous. On August 24 we reached Isafjordur, where we left the *Selis* and took the steamer to Reykjavik. We arrived in England in early September.

An expedition cannot set out without the goodwill and help of a great many people. I should like to express our warm thanks to Professor Arthur Hutchinson, the late Sir Percy Cox, Professor Sir Albert Seward, Professor Stanley Gardiner, Professor P. G. H. Boswell, Mr. J. M. Wordie, Dr. T. Franklin Sibly, Professor H. L. Hawkins, Professor C. E. Tilley, Professor H. H. Dixon, Mr. R. Miall, and Dr. Adolf Hoel. As on all Greenland expeditions, many Danes were most helpful, and I should like particularly to thank Mr.

Daugaard Jensen, Captain Ejnar Mikkelsen, Professor N. S. Nørlund, Dr. L. Koch, and Mr. Kraemer.

I wish to acknowledge generous grants made towards the cost of the expedition by this Society, the Royal Society, the Trustees of the Percy Sladen Fund, the Research Board of Reading University, the Trustees of the Gino Watkins Fund, and the Trustees of the Leverhulme Fellowships who awarded me a Leverhulme Fellowship for 1935–36.

British and Scandinavian firms assisted materially either by presenting their products or allowing generous discount; without this help it would have been difficult for the cost of the expedition to have been met.

APPENDIX I: GEOLOGY AND GEOMORPHOLOGY

L. R. Wager and W. A. Deer

There is a striking contrast at once apparent to the traveller between the mountains of Knud Rasmussen Land and those round Kangerdlugssuak. The former, carved out of almost level, basalt flows, show bands of snow alternating with horizontal black cliffs, while the Kangerdlugssuak mountains are more shapely peaks cut from the essentially massive gneisses of the Metamorphic Complex. Between the Metamorphic Complex, which is probably Pre-Cambrian in age, and the Tertiary basalts, there are in places several hundred feet of shales and sandstones.[1] In the lower sediments a few fossil belemnites were found; being marine organisms, they prove that this part of the sedimentary series was deposited in the sea. Professor H. H. Swinnerton has kindly examined the belemnites and deduces that the age of the lower sediments is Upper Cretaceous. The upper, more sandy, estuarine sediments contain impressions of fossil plants which Professor Sir Albert Seward has kindly examined. He has found them to be comparable with forms from the Mull Leaf Bed, and hence late Cretaceous or early Eocene in age. These few fossils are important because they show that the basalts which immediately overlie the sediments are Eocene. Thick dolerite sills, often columnar, have been injected into the sediments and are conspicuous in the field. The thickness of the basalt series in various places has been estimated by careful observation of the dip. In Miki and Irminger Fjords there are 7 kilometres of basalt with subordinate volcanic ashes near the base, and it is certain that a considerable thickness of the upper lavas has been eroded away. Inland, in the Watkins Mountains, and in the Prince of Wales Mountains, the thickness is 4 and 3 kilometres respectively. In both these districts it is likely that very little of the basalt series has been removed by erosion.

In the sequence of geological events to be deduced from a study of the area there was first a period of violent mountain building and igneous activity, probably in Pre-Cambrian times, which produced the gneiss of the Metamorphic Complex. Then followed an enormous interval of time during which the gneisses were eroded to a fairly even surface at about sea-level. In late Cretaceous times slight sinking in certain places allowed the formation of the marine, and then the plant-bearing sediments. At this time the country round Nansen Fjord and the inland regions also stood up above the sea as low islands, and no sediments were deposited. Then came the Tertiary igneous activity, and the vast pile of

[1] Wager, L. R., "General geology from Angmagssalik to Cape Dalton," *Medd. om Grønland*, Bd. 105, No. 2.

lavas built up of many hundreds of individual flows was poured out from volcanoes whose positions have not yet been determined with certainty.

After the extrusion of the basalts, but connected with the same subterranean igneous activity which produced them, large intrusions of igneous rocks were formed which cooled slowly to coarsely crystalline, massive rocks. Although the sediments and lavas were examined and collected extensively, so that a detailed understanding of them can be reached, our main work was carried out among the varied rocks of the three largest plutonic intrusions. The Skaergaard Intrusion, made of an iron-rich gabbro of unique type, is in the shape of an inclined inverted cone. The gneisses and basalts formerly occupying this space were pushed upwards, producing a mound 10 miles across on the surface of the earth. This has now been eroded away, and the deeper part of the intrusion exposed. We mapped the Skaergaard Intrusion on a scale of 1 : 50,000 and collected about a thousand accurately located specimens. The mapping of the Cape Edward Holm Intrusion, which stretches from this Cape to Amdrup Point, and the Kangerdlugssuak Intrusion lying to the west of the main fjord was carried out in somewhat less detail. We were able to show that the Kangerdlugssuak Intrusion, which is 16 miles across and contains the nepheline syenite near its centre, has reached its present position by quite a different process from that of the Skaergaard Intrusion. The molten magma underlying the solid rocks of the crust gradually ate its way upwards, incorporating first the gneisses and then some of the overlying basalts. The basalts have been completely removed by denudation from the whole area near the Kangerdlugssuak Intrusion, but that they once covered the region is proved by the engulfed blocks.

A late phase of the igneous activity was the formation of a dense swarm of dykes, which is remarkable in following closely the general direction of the coast and thus makes an abrupt bend at Kangerdlugssuak, from an east-north-east to a north-north-east direction. The dyke swarm was formed at the same time as, and partly as the result of, down-sinking of the crust to form the Denmark Strait. Concomitantly a dome-shaped uplift was produced inland whose centre is approximately at Cathedral Mountain on the Frederiksborg Glacier.

The present mountains have been cut by slow erosion from the uplifted dome. The lavas have been completely stripped off from the central and western parts and the underlying gneisses exposed. The impressive south wall of the Watkins Mountains is a scarp produced by the partial removal of the lava at the crest of the dome; it is not therefore due to faulting, as Dr. Koch has maintained. The Watkins Mountains themselves are a dissected plateau whose upper surface is not far removed from the original surface of the dome. Relics of the original surface of the dome are preserved in Gronau Nunataks and Seward Plateau, but elsewhere there has been enormous denudation. As has been previously suggested by one of us,[1] the probable reason for the preservation of the plateau in certain places is that an immobile cover of ice has protected it from the usual agents of erosion ever since the time of uplift. Another remarkable feature of the topography is the way in which the Christian IV Glacier and the Kangerdlugssuak Glacier and Fjord cut across the dome. We believe that the cause of this behaviour is that erosion of the valleys has been by glaciers and not by rivers.

[1] Wager, L. R., "The form and age of the Greenland Ice Cap." *Geol. Mag.*, vol. lxx, p. 145.

APPENDIX II: BOTANY
(With a Note on the Zoological Collections)

H. G. WAGER

The Kangerdlugssuak area has been the subject of several botanical investigations between 1929 and 1934 and the flora of the district is fairly well known, both as regards the species found and their more detailed distribution. A collection of plants was made, which is being named by Mr. A. J. Wilmott, of the British Museum; but the botanical work was concentrated on a study of the reactions of the plants to the arctic climate. This was attempted by collecting data for a comparison between the ordinary processes in the life of the arctic plants and the same processes in temperate or tropical plants. To this end three properties of plants were mainly studied: their rate of respiration, their rate of photosynthesis, and the changes in the concentration of the cell sap throughout the year. In all cases the main emphasis was laid on the effect of temperature on these processes, as this is probably the most important climatic difference from temperate regions. All this work was laboratory investigation and was carried on continuously throughout the year.

In the field, several studies on the life of the plants were made. The most important was a detailed investigation of the rate of growth of the plants in the earlier stages of development by mapping the plants growing on various selected small areas or quadrats in two successive summers.

The date when the flowers of those species growing near to the Base first came out was noted. The purple saxifrage (*Saxifraga oppositifolia*) was the first on May 4. It is interesting to note that this was the first plant found to flower by P. Gelting (*Medd. om Gronland*, Bd. 101, No. 2) in latitude 72°–76°, but there it was not in flower till May 23. Apart from this initial similarity the sequence of appearance of the flowers was very different in the two places.

Plant collections were made on many journeys carried out by members of the expedition. An interesting collection of lichens was made by Fountaine from nunataks near to the Ice Cap round the head of Kangerdlugssuak. Both flowering plants and lichens were collected on the journey to the Watkins Mountains in 1935. On this occasion lichens were found growing to an altitude of about 11,000 feet. During the journey to within about 15 miles of the Ice Cap, up the west side of Christian IV Glacier, in the summer of 1936, some sixteen localities were thoroughly collected, algae, lichens, mosses, ferns, and flowering plants being obtained. At the most inland locality, 60 miles from the sea, flowering plants were found growing to an altitude of about 7000 feet. Large areas of red snow were seen on all the glaciers travelled over on this journey and green snow was seen on one small tributary glacier near to the head of Christian IV Glacier. As a result of these various journeys a fairly complete idea was obtained for this part of Greenland of the plants likely to be found growing on the nunataks right up to the edge of the Ice Cap.

Light intensity measurements were made by an electrical method on selected clear days through the year. The total white light intensity and also the intensities of certain coloured lights were measured at frequent intervals throughout the day.

During the year zoological collections were made by Chambers. The collection of insects has been presented to the Hope Department of Entomology at Oxford where they are being worked out; a small collection of skulls and bird skins have been presented to the British Museum, and a collection of narwhal embryos has been presented to the Zoological Department of Reading University, where the development of the narwhal tusk is being studied.

APPENDIX III: METEOROLOGY

GORDON MANLEY

Meteorological observations were maintained throughout the period of the expedition's stay at Kangerdlugssuak. Pressure was read from a Casella mountain barometer and a Casella barograph. Temperatures of the air were taken thrice daily, at 12 h., 18 h., and 23 h. G.M.T. in a Stevenson Screen, and the daily maxima and minima were also read. Wet bulb temperatures were recorded while the temperature was about or above the freezing-point during September, and from mid-May onward. Record was also made at the hours of observation of the direction and strength of the wind; the visibility; the amount and type of cloud present; and the amount of precipitation, with additional notes on miscellaneous phenomena such as aurora, mirage, and gustiness of the wind. A further series of records was kept during the extensive high-level sledge journeys. The observations form a valuable contribution to the meteorology of the Greenland coast, and Mrs. L. R. Wager and Mrs. H. G. Wager were mainly responsible for their regular maintenance.

The screen was erected 95 feet above sea-level close to the backbone of a small rocky peninsula (Fig. 1). It may be observed from the map (Fig. 3) that the surface air currents could scarcely be expected to be other than north or north-east, or from between south and west. At the same time strong wind disturbance was frequently seen and heard from the main fjord some 3 miles or more distant; on these occasions it was common to experience light or moderate winds only at the Base, but interrupted at times by heavy gusts. This was not unusual if the general wind above was easterly. Gusts also occurred in the midst of quiet days, associated with the outflow of air above a quiet inversion layer lying in the lee of the coast; temperature rose rapidly, as might be expected, when such gusts occurred in winter. Winter winds were almost invariably north, or north-east, but it appears that a violent wind down the main fjord is not necessarily associated with outflow of air from the Ice Cap. It may sometimes occur with the piling up of a mass of Atlantic air from the east over the whole mountain region lying between Kangerdlugssuak and Scoresby Sound, and some of the strong north-north-west fjord gales may be attributed to the outflow of such air down the constricted channel with a gradient favouring north-easterly winds. Many of the instances of fjord gales in the morning appear to be katabatic, associated with great radiation the previous night from the mountain region above, with at the same time, so far as can be judged from the weather maps, a favourable general pressure gradient. A few instances of true föhn occurred with very low humidity, strong fjord wind, and falling barometer, on the rare occasions when the centre of a depression crossed Central Greenland; the highest temperature of summer (62° F.) occurred on several days in May, June, and July, but the May and June instances were each associated with föhn. Summer winds were almost equally divided between light breezes from north and from south points; the Base lay near enough to the sea to be affected by the sea-mist which occurred intermittently from the last week of May to the middle of September. On the coast however the mist lies usually a little above ground-level, so that there is moderate visibility at ground-level with dull grey cloud perhaps 200 feet above. Only two observations in the whole year are recorded of surface visibility of less than 200 yards without precipitation.

Kangerdlugssuak is of particular interest as it lies between the sub-Arctic region of South Greenland, with relatively high precipitation, and the dry north-east where Myggbukta (73° 30′ N.) has given an average of about 4 inches

of precipitation annually, measured as rain; Scoresby Sound (71° N.) over five years has averaged 13 inches; Angmagssalik (65° 36′ N.) 35 inches. During the year's observations, August 1935 to August 1936, the Kangerdlugssuak station (68° 10′ N.) had about 25 inches, falling on 119 days, but on only 86 days was the precipitation more than "a trace." "Rain only" fell on nineteen days. It appears probable that the year as a whole was decidedly drier than normal; and two months, November and May, together provided over half the year's total. Snow covered the ground from October 6 to mid-May; the first snowfall occurred on September 15, the last on June 7, except for some sleet on August 11. Precautions were taken to eliminate to some degree the drifting of surface snow into the rain-gauge.

A summary of the records of temperature and precipitation at the Base is given in Table I and the graph (Fig. 2). September was exceptionally fine, with persistent high pressure over Greenland generally; conditions became increasingly unsettled in October and November. It is clear that in this latitude temperatures above freezing-point only occur from early November to the end of March with the occasional advent of Atlantic air at the surface, usually from a region to the south-east of Iceland. A few days of thaw (up to 43°) in mid-November, and a temperature of 39° F. on February 9 each occurred under similar circumstances; but, in general, incursions of Atlantic air in this latitude are at high levels and surface temperatures through most of the winter months remained below freezing-point, with quiet cold weather and moderately clear skies. The passage of depressions to the south had often no more effect than to cover the sky with cirro-stratus; but a prolonged north-easterly current from the Norwegian Sea generally brought a little snow. Winter temperatures as usual in Arctic latitudes varied far more with the amount of wind and the dispersal of inversion layers than otherwise, and considerable fluctuations occurred almost daily, giving the appearance of a large daily range. May was exceedingly unsettled and snowy, especially at higher levels; persistent high pressure towards Scandinavia was associated with a series of vigorous lows travelling up Denmark Strait. Gradually summer conditions, open water near the coast, and frequent low cloud and mist, became established, with an almost daily sea-breeze bringing down the temperature sharply from about 50° F. to the upper 30's in the early afternoon. Unsettled weather in the summer and rain or snow occurred with lows in Denmark Strait, as might be expected; such lows in winter tend to move east rather than north-east and to have little effect at Kangerdlugssuak beyond a temporary increase in wind and cloud. It is probable that the width of the ice off the coast and the consequent growth of an inversion layer above it are of great importance in checking the advent of precipitation and surface thaw during the winter. From the limited observations available summer precipitation also appears to be heavier in ice-free years.

The observations taken during the extensive sledging journeys cannot be reviewed here, but one may note the exceptional fluctuations of temperature among the mountains near the edge of the Ice Cap; *e.g.* between March 28 and 29 temperature at 6500 feet fell from +7° F. to −51° F. This was associated with clearing skies after snow, the southward passage of a cold front, and the advent of air from North Greenland. A fjord-gale and very low temperatures (down to −13° F.) followed at the Base. Attention may also be called to numerous observations of glacier winds wherever slopes occur, and of the frequently visible drainage of air towards Kangerdlugssuak accompanied by a shallow surface-drift of snow.

TABLE I

	1935					1936							
	Aug.[1]	*Sep.*	*Oct.*	*Nov.*	*Dec.*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*[1]
Mean temp.[2]	(41)	33·2	24·2	25·6	12·5	3·6	5·1	9·1	23·9	36·8	38·5	43·8	(41·7)
Mean of all the daily max. ..	—	39·3	28·4	31·6	18·9	12·0	14·1	17·5	39·3	46·6	46·6	50·7	(49·1)
Mean of all daily min. ..	—	28·1	19·4	18·9	4·6	−6·6	−5·3	0·5	13·7	30·6	31·9	37·6	(35·9)
Extremes—Max.	(53)	46	37	43	31	23	39	31	50	62	62	62	(57)
Min.	(31)	22	10	5	−6	−14	−22	−15	−11	24	26	31	(32)
Characteristics	Fine	V. Fine	Rather unsettled	Very unsettled: mild	Variable to fair	Fine, cold	Mainly fine: average	Fair mostly	Often fine, warm after beginning	Mild V. wet	Mainly fair	Fine	Mainly fair
Fjord gale in main fjord: days	—	2	17	13	8	8	2	6	2	4	4	2	(5)
Precipitation: amount as inches of rain	(trace)	trace	1·8	5·9	1·7	trace	1·9	0·8	2·0	6·4	1·8	0·7	(1·84)
No. of days	3	2	13	12	5	4	7	15	14	18	15	8	5
Fog at observation hours (without precipitation); vis. less than 500 yards	?	3	0	0	1	0	4	0	0	2	0	0	1

Prevailing wind: northerly, light or moderate, except for short periods in summer when light sea breezes occurred. Mean force on Beaufort scale 2·1 at Base. Gale force recorded at Base on 4 days only. Fjord gales were observed during some part of 73 days, of which 46 were within the period October 5 to January 15.

Total precipitation for year August 19 to August 18, 25 inches approx., on 119 days (86 measurable). Total depth of snow, 15½ feet.

Mean cloud amount in tenths, 5·6.

[1] August 7 to 31, 1935 and August 1 to 19, 1936.

[2] Temperatures were taken at 10 h., 16 h., and 21 h., time of 30° W.

APPENDIX IV: FOOD

The sledging rations based on the reduced rations of the British Arctic Air Route Expedition were as follows:

	oz. per man per day	
Bovril pemmican	6	
Western margarine	6	Protein 147 gr.
Spiller's Army Biscuit	4	Carbohydrate 260 gr.
Glaxo Full Cream milk powder	2	Fat 275 gr.
Tate and Lyle cube sugar	3	
Cadbury's chocolate	3	Fat/Protein 1·7
Scott's oats	2	Fat/Protein and Carbohydrate 0·62
Dried mixed vegetables	½	Calories=4200
1 B.D.H.—Vitamin C tablet		
1 Park Davis—Vitamin A and D capsule	—	
	26½	

Professor J. C. Drummond very kindly considered this ration before we left, and the estimates of protein, carbohydrate and fat content are due to him. He thought that we should find a ration providing only 4200 calories a day would be slightly low. This seemed to be confirmed by our experience on the spring Ice Cap journey when after the first week we became increasingly hungry. Probably two or three hundred more calories would have been desirable on a really long journey in winter. During the first ten days of the summer Ice Cap journey, Fountaine made tests to find out if the fat in the rations was producing ketosis. The morning test sometimes gave negative and sometimes slight positive results and suggested that any increase in the proportion of fat would be inadvisable. We were in the habit of eating the bulk of the carbohydrate for breakfast and lunches and the bulk of the fat in the evening, and Fountaine suggested that the slight ketosis sometimes present in the mornings would disappear if the fat had been consumed more evenly throughout the day. After ten days on the above ration Fountaine and Deer reduced the margarine by 2 oz. per day and increased the biscuit and sugar by 3 oz. When they returned after five weeks on this ration they were extremely fit and had no craving for more. It is likely they would not have felt so satisfied on 27½ oz. if their journey had been at a colder time of year. The dogs on their ration of 1 lb. of pemmican per day were lean and hungry after five weeks' sledging in the early spring, but after the same time and distance in the summer they were still in perfect condition.

On the British Arctic Air Route Expedition, Watkins used to maintain, half frivolously, that he had arranged that the food at the Base should be sufficiently uninteresting to encourage parties to go off for journeys to enjoy the better sledging rations. Much of our work during the last year was done at or near Base, and our policy was to have as varied and as satisfying food as could be arranged. The fact that two wives were of the party made this easier. We had fresh meat all the year, yeast bread made from a dried yeast packed in tins by the Distillers Co., Ltd., and abundant dried vegetables and fruits. During the winter we took a daily ration of Vitamins A, C, and D. Several of us noticed that if A and D were forgotten for ten days toothache began, which would be removed after taking the dose regularly for a week.

DISCUSSION

Before the paper the PRESIDENT (Professor HENRY BALFOUR) said: Our lecturer to-night, Mr. Wager, is well known to this Society, and he is going to describe to us the work which he has done in the Kangerdlugssuak area of East Greenland. Mr. Wager has visited Greenland on three occasions and is therefore eminently competent to speak about that region. His principal interests are geological, and he has paid special attention to the physiography of mountain ranges. He has a great deal to say to-night and many slides to show, and I must not intervene to any extent; but I might also mention the fact that he has had considerable experience in dealing with the geological features of mountains in the Himalaya region, so that he is very broad-minded and a real authority. I am sure we are all looking forward to hearing what he has to say in regard to this easterly Greenland area, in which he has specialized so much.

Mr. Wager was formerly a member of the Watkins Expedition and has also worked with Ejnar Mikkelsen. On the last occasion he organized an expedition of more or less unusual character, because I think probably for the first time in the history of East Greenland exploration a number of ladies accompanied the expedition and, I believe, enjoyed themselves thoroughly. I will call upon Mr. Wager to give us his lecture and show us the slides with which he is liberally provided.

Mr. Wager then read the paper printed above, and a discussion followed.

The PRESIDENT: Dr. Fountaine is present and I am sure we would like to hear something from him.

Dr. E. C. FOUNTAINE: Medically, of course, the expedition was very sound. I was only called upon on two occasions, when I had to extract two teeth from members. There were however one or two rather interesting observations made. On one occasion Widimina, Enoch's wife, asked me to cure her cystitis. She said she had been treating it herself for some time, but it had not cleared up. I was rather interested, and asked how she had been treating it; she replied that she had been eating a lot of fat. Apparently that is a traditional treatment among the Eskimo, but it is only within the last fifteen or twenty years that we ourselves have treated the same condition by giving excess fat in diet.

During the winter some of us suffered from toothache due to dental caries. We therefore doubled our dose of vitamin D and the trouble rather miraculously cleared up in about ten days. I was discussing the matter this afternoon with a dental surgeon, who said, "But you all had your teeth attended to before you set out?" I replied in the affirmative, and he added, "Even if you were short of vitamin D and there was a deficiency in calcium metabolism, you could not get dental caries." We concluded that if, owing to laxity in the care of one's teeth, there were a hole in the enamel, dental caries will set in rapidly if there is a shortage of vitamin D and a deficiency in the calcium metabolism.

The experiments which I carried out on the Eskimo were unfortunate because all the chemicals decomposed and my technique was at fault. I did however carry out some very interesting experiments on the kidney excretion of the Eskimo. Chambers and I, living on a carbohydrate-free diet, found ourselves in a state of great irritability and disliked it intensely, and by chemical tests found that we were suffering from marked ketosis, whereas the Eskimo reactions were normal. That experiment has been carried out in more detail by an American in North Canada.

There is one other interesting medical point. When Deer and I set out on

our summer journey the ice was getting rather thin and we got a ducking. We dried ourselves after getting ashore, and three days later, when we reached camp, Deer said to me, "I am very cold." Actually it was quite warm and sleeting at the time, but he got into his sleeping-bag. I was quite warm then, but half an hour later I turned cold, and followed his example. We shivered in our bags for some time and then he said, "I'm very hot; I'm sweating," so he got out; and half an hour later the same happened to me. We made a hot brew; then we both took our pulse-rate. There was a little rise, but that was possibly psychological. We both felt a rather raw sensation in our chests. One does not expect infection in such regions, but that was presumably an infection of some sort, either virus or bacteria, which, as far as I can gather, is almost unknown in the Arctic.

The PRESIDENT: Mr. Deer was one of the geologists of the party. I would like him to address the meeting.

Mr. W. A. DEER: I might say a few words about travelling with the Eskimo as I travelled a little longer than any of the others with Hansi. Short journeys with the East Greenland Eskimo we found to be excellent as long as they were confined to travel on the fjord-ice. On the ice he was completely at home and of course much more experienced than we under those conditions. Mr. Wager found their experience almost essential during the early summer when the ice was thin, and even in the winter during a trip with Hansi to the head of the fjord, where the pressure from the Kangerdlugssuak glacier had produced lanes of open water and many pressure ridges, I found his skill and knowledge invaluable. The surface in this part of the fjord consisted of frozen brash ice making sledging very difficult and requiring a more expert knowledge of dog-driving than most of us had acquired. In the early spring Hansi was persuaded to do a short ten-day journey with me into the mountain region on the western side of the fjord. This entailed a certain amount of rope work on crevassed glaciers, and although the Eskimo has no method of protecting himself in this kind of country, which he usually avoids, he showed considerable willingness to try out our methods. Although he did not enjoy our sledge rations, the fat and pemmican being surprisingly difficult for him to assimilate, I was able to keep him travelling the scheduled time. His enterprise was however rewarded and his dietary troubles solved by getting a bear at a time when they were very scarce round the Base. Nevertheless he was very glad to return to his family, and every night told me that if I fell down a crevasse it did not matter, because I was a bachelor, whereas he had a wife and three children dependent on him.

The PRESIDENT: Is Mr. Augustine Courtauld in the hall? I know his way of hiding himself away in a mountain of snow for months on end, but if he is not hibernating at this moment he would be a welcome contributor to the discussion.

Mr. AUGUSTINE COURTAULD: I am afraid this is likely to be the only boring part of the evening, but I think a word is necessary from some one who was not on the expedition, and I should like just to say what a very good show it has been.

I think you have probably a rather confused idea of exactly where all those journeys went, and what they all did. Nobody could possibly describe a year's work in one hour, and this was a particularly complicated expedition because it was working the whole year on several very difficult scientific problems. I want you to try to realize the scale of the country, which I think Mr. Wager omitted to explain. That fjord which we saw on nearly all the maps, Kangerdlugssuak Fjord, which looked rather like a dead twig, is actually 40 miles long, and those peaks which he was rather ashamed of not having gone up are mostly 7000 feet straight up from sea-level. It is a big country and it is not just typical of the Arctic. You cannot read up a book on the Arctic and go out and use the

ordinary technique of sledging and hunting there. You cannot even take advantage of what other people have done last year in the particular region, because one year the ice goes out in June; the next in October; one year gales stop in the spring, the next they do not; and the last summer we went the whole fjord was entirely blocked with icebergs, whereas in 1930 the ship was able to get right up to the head of the fjord.

In spite of all that, Wager seems to have succeeded in making all the journeys he wanted to, and those journeys, although they look small on the map, were in fact 200, 300, or 400 miles each, right round the bounds of the fjord. Each journey involved not simply sledging but mountaineering, getting up steep slopes with dogs and getting up from sea-level, then up a 6000-foot peak and down again, as well as deep-snow travel and hard-ice travel. As you could see when Wager showed you the temperature chart, a single meteorological change, just for a day, entirely ruined the conditions for the season and made what was sledgeable snow into crystalline ice, which ruins the feet of the dogs and may produce a disaster if every contingency has not been allowed for.

I think you can assume that the expedition was led by a man who thought the whole thing out extremely carefully, and if he has any secret of success beyond his own experience and competence I think the secret is simplicity. He was not cluttered up with wireless sets and aeroplanes, or with a highly technical crew of people who could only do one thing. All his men, and the ladies too, were competent to do all the jobs of the expedition while he relied on himself and his brother for the expert knowledge necessary to carry out the expedition's programme, and on the Eskimo for their technical knowledge of hunting. That seems to fit in perfectly because no one can hunt as well as the Eskimo, however hard he may try, and it leaves the other men on the expedition free to do the scientific work.

I should like to say how very much I admire the whole conduct of the expedition and how very interesting I think this lecture has been.

The PRESIDENT: I have referred to the fact that ladies accompanied this expedition for the first time, and I did venture to remark that they thoroughly enjoyed themselves. But after hearing the kind of work which was put upon them and described by Mr. Wager himself, it is possible there may be some difference of opinion, and, as in these matters it is just as well to get first-hand knowledge, I will endeavour to persuade Mrs. L. R. Wager to come on to the platform and give her experience.

Mrs. WAGER: I think we were all extremely fortunate to be able to spend a year in East Greenland. It is a very beautiful country indeed. My sister-in-law and I certainly did the drudgery work, such as washing up, cooking, and baking of bread, but we enjoyed it all very much. I thought the winter might be a little trying during the dark months, but I did not find it so. When the men were away we spent hours in the Eskimo house, talking with them, and they came over to our house, generally just at meal-times so that they could share the meal with us; and we had an arrangement whereby the Eskimo came to tea every Sunday. We used to fill them up with biscuits and jam, and then we had to entertain them afterwards. The gramophone came in very useful for that, and when the snow melted from our large door-step we used sometimes to dance outside, once in a very heavy snowstorm.

I remember noticing, just before we left on the Norwegian sealing ship, that the top 1000 feet of the mountains were covered with the new winter snow and the bay-ice in front of our house was frozen over. I felt we had really seen the whole year round in the Kangerdlugssuak region and that a new winter was already setting in.

The PRESIDENT: We are fortunate in having here to-night a distinguished visitor, Mr. Ebbe Munck. The expedition owed so much to the Danes for the help they gave that it would be a pleasure to hear one of themselves speaking.

Mr. EBBE MUNCK: It is a bit of a surprise to be called upon to-night and, I venture to say, not a very pleasant surprise; first of all, because I am not used to making speeches in a foreign language; secondly, because I have not any fresh information to give you on the subject. But being on the platform, I take the opportunity to congratulate Mr. Lawrence Wager and his party on behalf of the Danish people who follow his work with keen interest.

It seems to me a long long time since we left Mr. Wager, at the end of August 1935, in Kangerdlugssuak. I had the privilege of being a member of the sledge journey to the Watkins Mountains and of the party which actually climbed the peak. Not being a climber or an explorer, I am very much indebted to my British friends; probably it is only because of their qualities and their patience that I myself managed to get on to the peak.

Lawrence Wager is well known in Denmark, and very highly respected by those who administer our colonies. I know our people will always be very happy to extend their hospitality to him whenever he goes to Greenland.

The PRESIDENT: I am sure, ladies and gentlemen, that you will agree with what has been said by Mr. Courtauld and Mr. Munck as to the admirable way in which this expedition was organized and carried out. It was intended to carry out strictly scientific research, and, as you can see even from the brief account which has been given to us to-night, the objectives were achieved in spite of the difficulties which militated against the carrying out of the entire programme.

We have every reason to be satisfied with what the expedition has done. The main results have still to be worked out in detail, but when that has been done the real importance of the expedition will, I think, become fully manifest. It has thrown light on an area of Eastern Greenland which was previously little known, and through the initiative and work of the successive expeditions which have ventured there we are now able to produce on the maps a real picture of that region; we also have more detailed knowledge of the actual geological structure to the study of which Mr. Wager was more especially devoted. This is a work admirable in every way and I think that Mr. Wager and his colleagues are to be heartily congratulated on having brought off their venture so successfully.

There is one word I would like to say in regard to the photographs. They struck me as being extraordinarily clear and extremely good. I do not know which of the members of the expedition was responsible for them, but I would like to congratulate him or her on that part of the programme which has been so admirably illustrated.

I must not prolong the evening. It is my duty as Chairman to push things on rather than delay them, and I will ask you to express your thanks to Mr. Wager for a very interesting paper summarizing, very briefly, an exceedingly valuable piece of field work.

PHYSIOGRAPHICAL NOTES ON THE ULLSWATER AREA

THOMAS HAY

Deltas

IN the *Geographical Journal* for July 1928 an article on "The shore topography of the English Lakes" pointed out that in many lakeland deltas the stream shows a curious curvature towards the head of the lake instead of pursuing a course in the median line of the delta or towards the edge nearer the exit of the lake. The author suggested an explanation of this fact, but it was rather far-fetched and unconvincing. When the paper was given at a meeting of the Society on 12 March 1928 Dr. Mill and other speakers admitted the existence of this "windward trend" but they showed a justifiable suspicion of the explanation. Further observation of these deltas has caused me to discard that theory completely and to adopt another which seems more likely to be the true cause of the phenomenon.

The main features of these deltas are: the outline is roughly semicircular, as the delta has mainly grown in extent and depth by overflow flood action directed from some point generally in the median line; where there is a predominant surface wind and a good expanse of water to windward, the stream through the delta often curves towards the wind, even when this means that it curves to the head of the valley; the edge of the delta in such cases is generally higher in the windward half of the delta than it is in the leeward half; and there is often a low-lying portion of the leeward half which is sometimes waterlogged and holds a considerable pool during wet weather. The third feature may be due to the waves raised by the predominant wind during heavy weather wearing away a noticeable segment and leaving a small cliff. Small material brought down the stream and often driven along the lee side of the delta may help to form a storm beach and to hold up surface water.

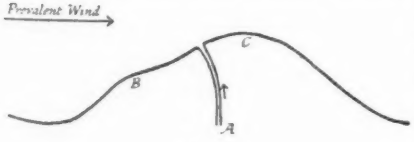


Fig. 1

Every delta must have experienced a great number of small catastrophes. Some variation in the beck may have silted up and raised its floor. The next sudden spate may burst a bank and create a new distributary. When this happened in one of the deltas under consideration the new waterway might occupy any position in the whole semicircle but there is one part of that semicircle which holds a better chance of survival. The law of unequal slopes comes into play.

If we call A in Fig. 1 the stream head of the delta and BC that portion of the edge which has borne the brunt of the storm attack and been most eroded, then the distance from A to any point in BC is likely to be shorter for the water than any other course and consequently the gradient will be steeper in that position. A new breakaway into such a position would thus offer a better opportunity of surviving even when similar incidents occurred again.

This explanation had a practical illustration in the case of the Glenridding delta during the period between September 1935 and May 1936. The long dry summer of 1935 had raised the bed of the beck as far down as the beginning of the delta and then very wet weather about September 12 caused both beck and lake to rise. The beck broke its right bank at the head of the delta and sent a new distributary at right angles to the old course of the beck. The new course had a much quicker and shorter fall to the lake, but in order to make a lasting deviation the water had to eat back through the foundation of the old right bank. During the high water of the flood only the upper part of this bank was carried away. This process now set in and the sill was gradually worked backwards towards the old stream course. At the first break-through about half the water adopted the new course and the other half kept to the old line. As the sill under the break got lowered more water passed the new way, and by the end of the month one could see that the new distributary had more water than the old. By the end of October the difference was more marked, and by the middle of January the new outlet was established as the main stream and was carrying about three-quarters of the water. There was a long dry spell in the spring, and on May 20 the new outlet was carrying off practically the whole output, the sill having been eaten down by the backward-working action of the steeper gradient in the new distributary. Thus the windward trend seems to be explained as follows: the delta tends to be semicircular like all others; the prevalent wind erodes a segment on that side of the delta facing this direction; and any subsequent outbreak of the stream towards this eroded portion furnishes a stream course which has a preferential position in comparison with others. Its shorter course to the water-level must have a steeper gradient, and this not only gives it a better chance to incise its bed but leaves it in what may be called a position of stable equilibrium. As this eroded portion faces the prevalent wind, the stream course shows a change of direction towards the prevalent wind ; hence the suggested name "Windward Trend."

Shore boulders

In the paper already referred to these boulders, when on the Glencoin type of shore, were explained as the hard remnants of a vanished part of the boulder clay surface which had been washed away by the wave erosion. This explanation is perfectly correct but it hardly explains those cases in which these boulders are actually arranged as if some one had placed them in a straight line parallel to the water edge. There are doubtless cases where man has used boulders to protect some specially valuable piece of good land, but that hardly covers the whole problem. There is a very straight string of boulders on the foreshore of Glencoin Park and another near Yew Crag in Gowbarrow Park, and in neither case has the land behind even been cleared of boulders. It has therefore not been specially valuable to man and no one is likely to have protected it. Again, the possibility of such boulders having been manhandled to get them out of the way when the ground was being cleared for road construction must not be overlooked. The boulders in question are too far away from the road for that. There seems no explanation which will account for these absolutely straight strings of a few boulders

in a few special places except that they may be the remnants of "lake ramparts" formed in post-glacial times when frost had a much greater effect than now. In the Sierra Club Bulletin VI, 1906-8, G. K. Gilbert gives an account of the formation of these ramparts in countries with cold winters such as Canada, the New England States, and Northern Europe, where ice-bound lakes develop great cracks due to contraction of the ice. A plate of ice 1 mile long would be shortened 1 foot by lowering the temperature about 7° Fahrenheit. These cracks may fill with water and freeze again, or, if channels are formed, they will form new ice. Then, when warmer weather comes, the ice expands, leading to a movement of the ice-sheet up the shores, and during this motion the boulders are carried shorewards and left there when the ice melts. This kind of action may have occurred in the past and it may account for these curious cases where the shore boulders are actually in a straight line and where no artificial action can be suspected.

Orientation of shore boulders

The shore boulders which are an inheritance from the valley glacier might be expected to be oriented lengthwise in the direction of movement of the ice, according to the usual rule. Ullswater runs due north from Glenridding to Glencoin, and then it changes to north-east or thereabouts. It was interesting to see how this sudden change was reflected in the orientation of the shore boulders. From Glencoin to the north-east end of Gowbarrow Park at Yew Crag there is a good run of the Glencoin type of shore, with a natural break at the delta of Aira Beck. The large boulders on this shore were classified into three groups: those lying lengthwise on the shore; those lying crosswise; and those which were indeterminate either because their position was half and half or because their shape was square. It was expected that the position of the boulders on the first part of the shore, from Glencoin to Aira Delta, would be anomalous owing to the sudden turn of direction at Glencoin. The numbers reduced to percentages gave the following result. Of the total number between Glencoin and Aira Delta 37·8 per cent. were lengthwise and 30·7 per cent. were crosswise. But along the second part of the course from Aira Delta to Yew Crag 51·8 per cent. were lengthwise and 11·5 per cent. were crosswise. If we divide the lengthwise percentage by the crosswise percentage in each case to get a measure of the adaptation of the boulder position to the new direction of the valley, we get 1·2 for the Glencoin end and 4·5 for the Gowbarrow end, showing how greatly the orientation of these boulders has been altered by their passage down this short distance of the valley.

Floods and rainfall

The accurate relationship of the lake-level and the rainfall for any particular lake can only be discovered from a protracted course of observations of the water-level and the rainfall in that particular catchment area. This does not seem to have been done for Ullswater, and a few observations may be of interest.

The response of the becks to heavy rain depends on the condition of the ground. If the latter be already soaked with water the response is more speedy

and in any case the response to real torrential rain is almost immediate. A very heavy thunderstorm, nearly overhead and accompanied by torrential rain began at 2 p.m. on 2 August 1934. By 2.15 the Glenridding Beck showed a definite small rise. Then the storm decreased slightly and there was a slight decrease in the stream in ten minutes. The storm then passed up the valley and increased in severity behind Heron Pike and over Raise. There was a definite larger rise in the stream within ten minutes. At 3.25 the stream was still rising and much higher than before. Heavy rain stopped here at 2.45. The stream was probably at its highest at 3.40, and the peak of the rain seemed to be about 2.30. This gives a lag for Glenridding Beck of one hour and ten minutes between the peak of the rainfall and the peak of the beck for such a short torrential fall.

The case of the lake is much more complicated. It responds fairly quickly to torrential rain, especially if the lake-level was originally low. The lag is very much more than in the case of the becks, and when the lake has reached

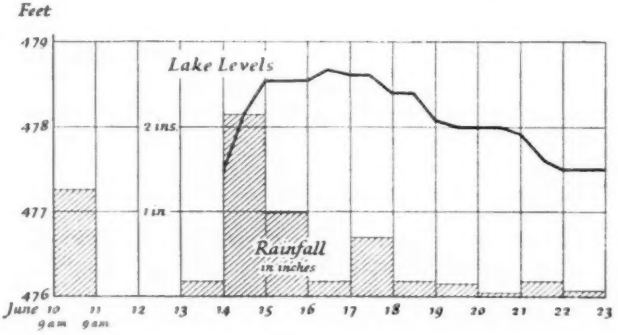


Fig. 2

its highest level for any particular rainfall it stays near that level for some little time and only falls slowly.

From observations on lake-levels made by Mr. Philip Moon, of Ullswater, and from the rainfall records of Patterdale Hall I have drawn two charts showing the relationship of these two factors for the periods 15 to 31 August 1930, and 10 to 23 June 1931.

Rainfall was measured at 9 a.m., and as usual the fall registered on, say, June 14 at 9 a.m. was entered as the fall for June 13, being the amount which had fallen between 9 a.m. June 13 and 9 a.m. June 14. It so happened that lake-levels were taken not only at 9 a.m. but also at 9 p.m., and this has helped to give more precision in the inferences.

The graph (Fig. 2) shows how prompt is the response of the lake-level to really heavy rain. Here the steep rise in lake-level on June 14—4 inches in 3 hours 10 minutes—was caused by the thunder rain which fell on that day itself, and then the considerable but smaller fall on June 15 caused the additional small rise in level which is registered on the 16th. If we regard the fall of June 14 as being concentrated round 9 p.m. June 14 and take that

point as the peak of that rainfall, and the height of the lake on June 15 at 9 a.m. as the peak of the lake-level for this first rainfall, then the lag is only twelve hours. If we do similarly with June 15 and take 9 p.m. as the peak of the rain, and the lake-level at 9 p.m. June 16 as the peak of the lake-level for this second day's fall, then the lag is in this case twenty-four hours. But it will be observed that the limitation of times of observation at once limits the possibility of inference, and the usual method of taking observations once a day means that the lag must come out as a multiple of one day, although in actual fact it will almost certainly not be an exact multiple.

The graph (Fig. 3) shows that the rain of August 18 made the lake rise, but it is the heavy rain of August 20 which has caused the steep rise registered on August 22. In this case however the heavy rain of August 20 cannot be differentiated from that of August 21, and it is better to regard the fall of

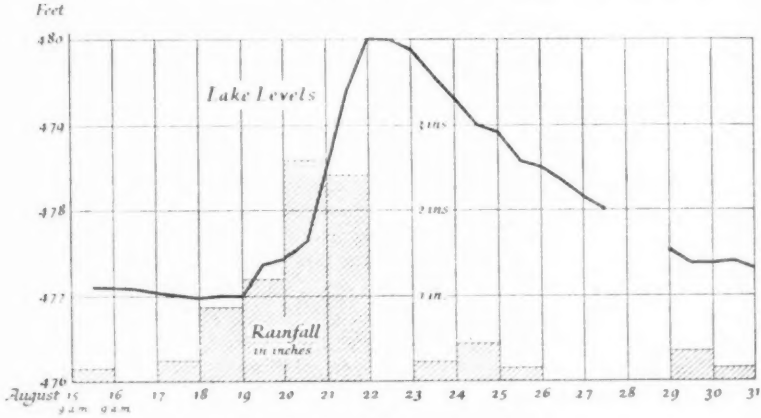


Fig. 3

these two days as one event. If we regard the peak point of this fall as concentrated round 9 a.m. August 21, we get a lag of 24 hours between the peak of the rain and the peak of the lake-level. In the case of one storm which I watched on 6 May 1934 the heavy rain ceased at 6 p.m. and the lake reached its highest point by 2.30 p.m. the following day. Thus there was a lag of 20½ hours. These rather scrappy details tend to show that in the case of heavy rain of comparatively short duration the lag of the lake-level is somewhere between 12 and 24 hours, but it may well be that in the case of more protracted heavy falls the lag is longer.

The fall of the lake-level after a heavy rainfall is clearly shown in Fig. 3. Heavy rain on 19, 20, and 21 August 1930 raised the lake to 480 feet, and it took the lake 10 days to recover its former level. This shows that although the rise of the lake-level is quick, its fall is comparatively slow. On this fact depends the value of lakes as a means of ponding back water and saving the country below from sudden floods.

A flood occurred in the Glenridding Beck on 3 November 1931 in which

that stream burst its bank and ruined a field near its mouth by depositing a huge quantity of stones and gravel. It also raised and partially choked up its own bed and added a considerable new frontage to part of the circumference of the delta. A calculation of these various deposits, without taking any account of what the beck carried into the lake, showed that something over 11,000 tons had been brought down. Many such incidents, though possibly on a smaller scale, make one realize that the chief work of transportation in such areas is effected by the catastrophes within the uniformitarian scheme rather than by the more prolonged periods of routine working.

Mr. F. Hudleston, in an interesting account of the floods of the Lake District,[1] concludes that in winter time if the ground is already soaked, 90 per cent. of the whole catch of rain eventually flows off the ground into rivers and lakes, although during summer an indeterminate amount is lost through evaporation, and a considerable amount may be required merely to wet the dry surface. But although the eventual flow-off may be 90 per cent. it is found that the "flood discharges in the valleys of the Lake District after periods of exceptionally heavy rainfall do not exceed 70 per cent. of the rainfall during the peak period of time, that is during the actual days when these floods give us most trouble."

From the records of many years kept by the Marshall family on Derwent Island, Derwentwater, and quoted by Mr. Hudleston, it appears that on that lake the greatest fluctuation in height is 8 feet 9 inches between the recorded lowest and highest points. Here on Ullswater several observers agree that 6 feet is about the limit of the variation, although if there were accurate observations extending over a long time that limit would probably be somewhat larger. This seems to be confirmed by some old records of lake-levels for Ullswater, covering the years 1863 to 1875, which show that the difference during those years between the lowest record and the highest record was 6 feet $2\frac{1}{2}$ inches.

Working on rainfall figures supplied by the Meteorological Office and on figures supplied by the Chief Engineer of the Manchester Waterworks for water-levels, Mr. Hudleston found that the peak of the discharges from Thirlmere was always a full 24 hours behind the peak of the rainfall. In the case of Derwentwater this lag was in one case found to be two days. It is found that Derwentwater is sometimes ponded up by the discharge of the river Greta back-watering up into the lake. But we are faced with a degree of uncertainty in determining the exact amount of the lag because the latter may actually occur at any point of the 24 hours, whereas the observations of level and rainfall are only taken at one fixed time per day.

Marsh lands around Ullswater are more waterlogged than they used to be, and this is due to the same cause that Mr. Hudleston has found operative in the case of Bassenthwaite: the neglect to keep drains and channels and even beck courses properly cleared. It is sometimes said that the outlets of these lakes are becoming silted up, but there appears to be no truth in this in the case of Ullswater, and Mr. Hudleston states that he has found no evidence of it in the case of Derwentwater and Bassenthwaite.

[1] 'Floods of the Lake District,' part I. Printed for private circulation by the River Derwent Catchment Board.

Scree movements

There are many points of interest to the physiographer in the screes which cover some of the fell slopes. Although there are no screes to compare in magnitude with those at Wastwater yet they occur in all the more precipitous parts of the area. Often other parts of the scree escape notice through becoming covered with vegetation. This may be due in some cases, as Dr. Marr suggests, to greater age, but very frequently it is due to greater stability or to special conditions favouring the growth of grass and other plants. The rock fragments descend the slope in several ways. First there is what may be called violent motion where the block hurtles down by pitching and rolling. In screes where this has been the main factor in their growth the larger blocks are found at the foot of the slope and the size of the various fragments decreases higher up. This scree is well developed as a rule at the foot of an impending cliff, although one can often find a fossil scree on the fell side in cases where the whole rock exposure has been broken up and has fallen in fragments.

Secondly, the pieces may descend by sliding action. In this case because the angle of repose is greater for large blocks than it is for small ones, it will often be found that streams of small fragments will make their way down the slope while the large fragments form a comparatively stable staircase. Thus the small particles may pour round and over the large blocks in those places where part of the rock has been more fissile and furnished with a closer assemblage of joint planes.

Descending water may assist the motion in all these cases by diminishing the friction, and by sapping and mining, thus removing the little supports that have held the blocks in place.

Great boulders

There is a special scree which may be called Great Boulder Scree or Great Talus. The French writers refer to this as "éboulis à gros blocs." Probably

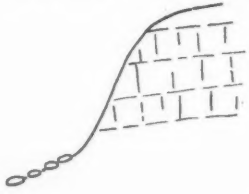


Fig. 4a

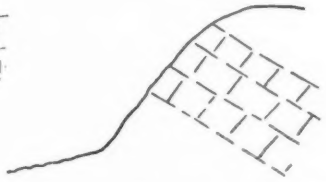


Fig. 4b

it was more plentifully formed at the end of the glacial period, but at the present day it is only formed in special places. In every case examined it has been found that the joint planes of the rock above have been so situated as to assist the discharge of the blocks. If the jointing of the two cliffs in Figs. 4a and 4b be looked at it will be seen that in Fig. 4a the cliff has a system of jointing which facilitates the discharge of big blocks as soon as weathering forces have sufficiently loosened them. In this case one may expect to get Great Block Scree and not in the case of the cliff in Fig. 4b. Occasionally one

finds a slope below such a cliff as that in Fig. 4a, when the large blocks are spaced out at almost regular intervals downwards on the slope below without any collection in any one place. This seems to show that the discharge of these large blocks must have been fairly methodical, and that the slow creep down the slope of the discharged blocks must have proceeded regularly.

Rock-falls on any considerable scale do not seem to be of common occurrence, but occasionally one comes across all the necessary arrangements *in situ* and ready to operate with a little encouragement. On the south side of upper Glencoindale a small cliff stands above a steep slope, and here, owing to the sapping and mining of percolating water and the position of the joints, an enlarged joint has created a considerable rift in the rock. It measured 20 feet high by 8 yards deep and 8 inches broad. Here some slight movement may soon cause a fall.

Landslipping

When it is remembered that the ice age has left the lower slopes of all these valleys lined with boulder clay, and further that this clay is often plastered on a rock slope which has a gradient but little greater than that of the clay surface itself, it will be easily understood that landslipping has accounted for a great deal of movement. Water finds its way between the rock and the superincumbent matter, and also along gravelly layers inside the clay itself. This lubricates the path, and when heavy rain has increased the weight of the mass, the rush takes place. Generally the result is a scar on the hill side and an expanse of hummocky ground below, both of which can be easily recognized. But a very old slip covered again with vegetation sometimes proves difficult to identify. Some anomalous and peculiar mounds are explicable best as old landslips, and go to show the prevalence of the occurrence. It seems to have been very frequent at Dowthwaitehead, probably when the drift-covered slope of Nameless Fell was washed by the waters of a now vanished lake.

Stone streams

Stone streams are really small narrow screes, and as in the case of screes they may still be in active motion or they may be fossils which have become coated over with vegetation. When stone streams are mentioned the term generally has reference to the older stone streams which have been formed by solifluction, and those will be mentioned later on when frost phenomena are dealt with. But stone streams may occur anywhere on the fell slopes and may be formed simply by the ordinary processes of gravitation accompanied by the sapping action of water. One of the best examples occurs in Latterbarrow Gill on the north side of Glencoin. It is a laborious job to scramble up this huge gash in the mountain slope owing to the mass of descending débris which fills the whole aperture. At the foot there is a very good cone or dry delta, but on the surface of this delta there is a later manifestation of rush methods which has a decided interest. The feature is a stone stream coming out of the gill mouth and lying on the surface of the cone. From this main stream some four branches go out, so that it looks like a narrow wrist and hand spreading out its fingers. This superimposed feature has

probably been formed by a huge mass of melt-water and blocks of rock pouring down after a sudden thaw and canalized by the still unmelted snow lying on the cone. The midday sun looks straight into the gill and may well have caused such a sudden flow. The lower end of these distributaries is about 660 O.D., and the breadth of the stone streams varies between 12 and 17 yards, their depth being about 5 feet.

There is a good example of an old stone stream on the west side of Hayeswater.

Orientations of blocks

The orientation of blocks which are still in slow motion or which have been in motion in the past may be of some interest. It will be remembered that stones on the beds of streams tend to lie in a well-known position, and this same position has been observed in a few cases in the lower parts of boulder clay. It has long been known that large erratics left by glaciers are often lengthwise in the direction of motion of the ice, but this does not apply to those quite near to the source of motion.

In the case of screes formed by violent motion no special orientation for the blocks has been observed, but in those parts of the scree where slow motion is the rule a certain orientation shows itself. Where big blocks are descending amidst a mass of smaller matter the larger blocks tend to orient themselves lengthwise in the direction of motion. This position is also noticeable in those parts of a damp slope where a good deal of slow sapping and mining takes place. A previous paragraph has shown that the shore boulders tend to lie lengthwise on the shore of the lakes, but this is only an inheritance from the ice motion during the glacial time. The subject of orientation is referred to below in connection with the frost phenomena on the summit land.

The becks

The becks are busy clearing the drift out of their valleys, and where the matter left by the ice is of the loose nature found in the combes and upper valleys the process goes ahead quickly. But lower down, where the drift is hard bottom boulder clay, the sides of the beck may stand up almost perpendicularly and the erosion is slower. The side valleys have been more liberally lined with boulder clay than the main valleys. It is not easy to see why this should be. The side valley ice came into the main valley at grade. It looks as if the main valley ice had actually dammed back the ground moraine of the side valley. The consequence is that many side valleys had a large deposit of ground moraine and the becks had a plentiful supply of matter to attack and remove. Nearly every beck in the whole area is running largely in drift, but also in nearly every case the beck has reached live rock in places, and this limits the amount of vertical erosion.

In some cases, as in the lower parts of Aik Beck and Elder Beck, the stream is actually on Skiddaw Slate, but the bed is so choked up with the much harder Borrowdale boulders from the drift that these latter take the whole brunt of the attack and protect the underlying softer rock. The total amount of matter that has been removed by the becks from these drift-lined valleys

since glacial times must be enormous, and it largely accounts for the great number of filled-up lakes and alluvial stretches that are such a characteristic part of the scenery.

Post-glacial and pre-glacial gorges

It seems quite impossible to be certain, by inspection of form only, whether a gorge has been in existence before the last ice covering or not.

There is a small gorge at the foot of the Glencoin Valley which brings this home very forcibly. It is quite a small feature above the farm by the old mill-race. Probably any one looking at this small gap would conclude that the incision was a post-glacial cut, but, on looking closer, one finds between some of the rock crannies hard yellowish-brown bottom boulder clay, proving that the last constructive incident here was the cramming up of the gorge with the bottom boulder clay which has hardly yet been cleared out. The Glenridding Beck by the Greenside Mine has one of the best gorges of this neighbourhood. The stream is largely a strike stream and the gorge has evidently been considerably deepened in quite recent times. Just above this position the ice must have halted for some time and the stream would be loaded with detritus to act as a powerful erosive agent. Here one would feel fairly certain that the gorge is very largely of post-glacial cutting, although the previous instance shows how doubtful the decision may be.

Stream banks

There are one or two features about stream banks which deserve notice. The first is that in several cases there are high banks made of boulders larger than those which the stream has to deal with at present. The banks are cambered outwards and were probably formed when a greater number of large boulders, the product of the ice action, were hurled down by the stream in periods of spate. At that time the torrent threw out boulders right and left as streams do, and they went to build up these noticeable banks. Then later the stream has cut down its own bed within the boulder mass. The result is that a cross section takes the form shown in Fig. 5.

Fig. 5

Such banks are very noticeable on Swarth Beck, Caudale Beck, and Red Tarn Beck. When the banks of a beck are formed of deep drift into which the stream has cut rapidly without giving the banks themselves time to weather back to a gentle gradient, the surface drainage cuts these banks into a series of very striking channels running down steeply from the adjacent land to the beck level. The best example of this is Cumberland Deepdale running down to Dowthwaitehead.

Fluted rocks and potholes

There is one distinction between the smoothing of rocks by water and by ice which is not often insisted on, although it was noticed long ago by Whymper. In Chapter VI of the 'Scrambles amongst the Alps' there is a striking passage in which he correctly calls attention to this difference. His reasoning on ice action was often faulty, but his observation was amazingly accurate. In this

case he notices that the essential characteristic of the result of ice smoothing is convexity whereas in the case of water smoothing it is concavity. Needless to say there are many convexities in the case of water smoothing, but that does not alter the predominant impression. In the case of ice smoothing the convexity is still more noticeable, but the concavity can also occur. Occasionally a block has been plucked out of a large surface of rock which had been smoothed, and in this plucked cavity the smoothing process has to begin again, and work under the added difficulty of the hollow. Even there the smoothing effect follows, provided no further piece of loose jointing leads to subsequent extractions.

These are merely the ordinary smoothing processes of ice and water, but in the upper part of Glenridding Beck there are two instances of a curious kind of fluting which I have not seen elsewhere. The flutes or channels are waterworn and are worked in the surface of waterworn rocks. The edges of the flutes are so distinct and sharp that one could almost cut one's finger on them. It is difficult to see how these flutes can have been eroded by the ordinary action of the beck, and yet the only other solution would be the action of water below ice and under hydrostatic pressure. Probably it is only an extraordinary instance of ordinary water action.

Later on another rock was found which showed at least one way in which this fluting can arise. The rock is fine-grained and possesses joints running in a direction not far removed from that of the beck. During floods, the impact of boulders on the bed of the beck removes slivers of rock bounded by cracks largely determined by these joint planes. These narrow sharp-edged clefts offer passages down which the water rushes. This swift rush of water loaded with sand down the length of the cracks rather than across their edges polishes them outwards and tends to keep the edges sharp. Although the rock in question is not noticeably cleaved, these joint lines run very much in the direction of the cleavage in their neighbourhood.

Potholes occur very frequently in fine-grained tuffs and andesites. One very curious case of a descending pothole was found in Glenridding Beck. Aided by a series of almost vertical joints this pothole had descended successively through three or four positions, adjusting itself to, and helping in, the vertical descent of the stream-bed.

Rates of erosion

Where a powerful but confined stream of ice travels down a valley with a velocity which may be described as glacially considerable, it undoubtedly results in the deepening and widening of the valley. This again leads to over-steepening of the valley slopes. But when ice action takes place under other conditions and without the advantages mentioned above there are some facts which suggest that the rates of erosion of ice and of sub-aerial weathering are approximately the same.

If one examines the slopes of the two great ridges bounding Red Tarn Combe, Striding Edge and Swirrel Edge, it will be observed that the north side of each is possibly steeper than the south side, but it will be seen that all the four offer gradients which are generally speaking continuous from top to bottom and show no definite change of slope. This may be seen in

photographs of the two edges which are sometimes quoted as good examples of the roof-ridge type of erosion. The same thing is noticeable in an illustration of a hill near Hartsop Hall given by Dr. Marr.[1] If the accepted explanation of the Glacial Epoch be correct, that it was a very long period with possibly interglacial times and certainly with fluctuations, and that there was a time of growth and a time of decay in each of these fluctuations, then in the end there must have been a very long period of time when there would be ice action affecting the lower part while sub-aerial action was progressing on the upper part of the same slope. Yet there is no evidence of oversteepening in the cases mentioned. The explanation may be that the rates of ice erosion and of sub-aerial erosion are often nearly the same. Högbom illustrates slopes which, despite a glacier, are not steeper for ice action than for the weathered part.[2] If this reasoning be correct, it may partially account for the battle that has been waged over the possibility and extent of ice erosion.

Questions of weathering

It is often assumed that sub-aerial weathering produces areas of subdued relief. But this is only the ultimate result; the first stages of the process may be the production of surfaces which are very much more rough and uneven than they were before the attack of the weathering forces. The forces tending to a subdued result are assisted if the products of disintegration can collect and accumulate around the disintegrating rock. But where these products are carried away either by the force of gravity or some other agency, the immediate result is a greater amount of roughness in the surfaces and a greater amount of variety in the scenery. This is especially the case in this area of Borrowdale rocks, in which there is such a variety of texture and hardness and such a difference in the position and character of the small and large joint planes. The moutonnée rocks in the valley bottoms are for the most part complete and entire in outline, but farther up the fell sides and on the lower parts of the ridges the moutonnée surface can be found in every stage of disintegration until in some cases it is only just possible to recognize the fact that at one time it was a smooth surface. Here is a proof of the statement that often the weathering forces produce asperities rather than rotundities.

On many portions of the fells the chief point of attack is the circumference of the rock where it sinks beneath the vegetation of the surrounding level. On this line where air and water can both assail the rock the effect is often visible in the creation of a little perpendicular cliff surrounding the remaining rock and marking the position of the vanished portion. The result of the action on these rounded masses is shown in the figure and it is a very common feature on the fells (see Fig. 6).

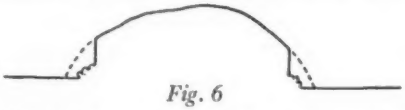


Fig. 6

The freaks of weathering are so various that it would be impossible to

[1] J. E. Marr, 'Geology of the Lake District,' p. 140.

[2] B. Högbom, "Über die geologische Bedeutung des Frostes," *B. Geol. I. Univ. Upsala*, 12 (1914), p. 289.

describe and catalogue them all. Swirrel Edge and Striding Edge are amongst the best-known ridges of the British Isles. They are very close together and in similar positions. They have been rough-hewn in similar manners but the final sculpture is quite different. In the case of Swirrel Edge, apart from the exposure of dolerite near the top, we have a rock which disintegrates in small slabs owing to the plentiful supply of cleavage and other divisional planes. These fragments at once begin descending the slope either by the ordinary creeping process or aided by solifluction which is evident on all the summit land. The result is a ridge noticeable for its even tenor. In the case of Striding Edge the dominating factors are three in number: the bedding is horizontal and is quite a distinct feature, the cleavage runs parallel to the ridge, and the rock itself is much more compact than in the case of Swirrel Edge. As the result of these three differences the ridge is characterized by great roughness and the disintegration shows itself in the displacement of great blocks of hard rock. The slope to the south of the more easterly part of Striding Edge is one of the roughest parts of this area owing to the pell-mell positions of these great blocks.

The influence of faults

The position of streams must often have been determined by the presence of faults. In the bed of the upper part of Glenridding Beck there is a wide fault which has been filled in with quartz as hard as the native rock. But lower down in the deep gorge which has been already mentioned, and in continuation of the line of faulting, there are foot-wide faults where the rock has become so soft that a sharp-pointed stick can be pushed into it. Another example of chemical disintegration occurs at the source of Sticks Gill where a considerable area of "White Trap" has been formed by the decay of an andesite exposure. This particular product of decay was rather misleading as it simulated the appearance of some special kind of glacial clay.

Surface effects

Amongst the many varied surface effects of weathering the commonest, and not the least noticeable, is the result in the case of many bedded tuffs. Here the lines of harder matter stand out in long continuous bands and make a very striking appearance. There is an example near Dowthwaitehead where the surface weathering of a good sound tuff gives exactly the appearance of the cup and ball markings that are such a puzzling problem to archaeologists. Here the result is due to some concretionary structure, and it is the only example that I have seen. Along the summit line of the Helvellyn range and in Ruthwaite Cove there is rock whose weathered surface imitates little craters, and again this is probably due to a concretionary nature.

There is a very striking flow-breccia in the bed of Glenridding Beck a short distance below the mine. A fresh surface shows little differentiation between the first consolidated blocks and the later lava, but surface chemical changes have produced a wide difference with the result that a very beautiful mosaic effect is shown. Instances occur in which a coarse breccia is splitting up *in situ* into a pile of blocks owing to the disintegration of the cementing lava.

Funnel and cone formations

The processes of weathering and cone-building sometimes combine to produce a result resembling the shape of the old-fashioned egg-boiler. Some special line of weakness has probably started the rock decay at the top of the valley wall, and frost and running water have elaborated a funnel-shaped excavation in the upper part of the cliff. This ends downwards in the constriction which separates the area of excavation above from the area of deposition below, and it also forms the passage down which the detritus works its way from the funnel to the cone. Högbom has called attention to these "Erosionsfurche" of "halbtrichterartigen Hohlform" accompanied by the "Schuttkegeln" down below.[1] But in an area where the frost effects are much less vigorous we never seem to get more than one of these formations developed in the same place. It is this factor which suggests that some special weakness has given rise to the funnel. There are noticeable examples of this form in Latterbarrow Gill, near Glencoin, in the nameless gully and cone at Cote in Fusedale and the nameless gully behind the Knott which has built up the great delta in Hayeswater. One more point may be mentioned: above the bottle-neck or constriction the floor of the gill is concave, like that of an ordinary valley, but below this point the floor is convex.

A common form of rock weathering

A form of rock weathering that takes place frequently in our dales is shown in Fig. 7. If ABCD is a simplified section across a valley wall, AB represents the scree lying at the angle of repose depending on the size of the fragments, BC the rock face, and CD the hill top covered with coarse vegetation and lying at a much less angle to the horizon than either AB or BC. The rate of rock weathering is dependent on the inclination of the rock face to the horizon and is greater where that inclination is high. As all the loose débris can work comparatively quickly off BC, the rock face is retreating parallel to itself while the scree is stretching farther up the hillside. On CD two factors retard weathering: the cover of vegetation and the comparative flatness. B′ and C′ are new positions of B and C after a period of weathering. The place where the disintegration is most noticeable is along the horizontal line through C, *i.e.* along the break of slope between the top and the rock face. Here the ragged edge of disturbed vegetation and of old quiescent débris is much more noticeable than the parallel line through B where the growth of scree is greater in quantity but less striking to the eye. The north and south faces of Sheffield Pike show this feature clearly.

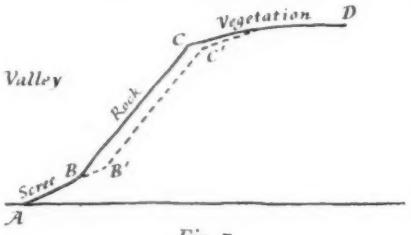


Fig. 7

[1] B. Högbom, "Wüsterscheinungen auf Spitzbergen," *B. Geol. I. Univ. Upsala*, 11 (1912), pp. 242–51.

Summit phenomena

Much of the highest land of our area is of a rounded nature and is covered with a coarse vegetation of grass and reed. On the rock exposures the weathering effects are taking place more vigorously than at lower levels, but the following notes are more concerned with other phenomena to which not very much attention has been paid so far in this country. Above a certain level there is a continual struggle going on between two processes. First of all, downward movement of materials, and especially frost effects and solifluction movements, are tending to destroy the vegetation, and, secondly, this vegetation is continually trying to repair the damage and to regain ground from which it has been temporarily ousted. The first signs of this struggle appear about 2400 feet O.D. where tiny breaks appear in the green covering presenting the appearance of little cliffs of the upper dark-coloured rooty soil. These are quite irregular and only 3 or 4 inches in height. Higher up the destruction of the vegetation may be so complete that patches of gravel are exposed with only one or two tufts of vegetation left here and there. It is on these surfaces that the stone stripes are developed which have been described by Dr. Hollingworth.[1] Only once on these Borrowdale Rock fells have I seen stone polygons. That was on a flat spur leading up to Raise in the Helvellyn range, and it was not a very convincing exhibition. Close alongside a patch with stone stripes one may see another patch which has evidently experienced the same history but where the vegetation has regained its hold. Some temporary change in the surface or underground supply of water or some alteration in the size of the gravel fragments may have caused the change.

In places it seems that the wind has had a good deal of influence in these patches of disintegrated vegetation because the little bare cliffs of turf are facing towards the south-west. The result is that as one looks towards the north-east the turf appears much more broken than when one looks to the south-west.

Terraces

At the heights where stone stripes are produced we also get small terraces. They usually measure 3 or 4 feet long by about 2 feet broad and lie lengthwise on the hillside, *i.e.* with their greater measurement parallel to the watershed above them. They are bounded on the side away from the top by a rim of vegetation which apparently has been saved from further collapse by the strength of the root fibres. The surface is of gravelly soil, and directly after a thaw the contents are quite mushy. The front grass walls of these terraces are 4 to 6 inches high. Each little terrace is quite level, so that a succession of them presents the appearance of an irregular natural staircase. From this regularly formed solifluction terrace all sorts of variations can be found between that regularity and the merest gash in the turf which would not be noticeable by itself. At the top of the stony area where the stone stripes are developed a progressive passage of the degradation of the turf can be observed

[1] S. E. Hollingworth, "Some solifluction phenomena in the northern part of the Lake District," *Proceedings of the Geologists' Association*, vol. XLV, part 2, 1934, p. 167. T. Hay, "Stone stripes," *Geogr. J.* 89 (1936) 47–50.

Fluting along joints, Glenridding Beck

Block weathering in coarse tuff, Hart Crag

Solifluction terraces, Helvellyn

Stone stream at Glencoin

Cup and ball weathering, Randerside

Crater-like weathering, Dollywaggon

between these solifluction terraces and the bare stony area. At times an irregular grassy terracing is seen on the summit land due to the grass having re-established its sway over some of these small terraces.

Turf patterns

On the comparatively level or gently sloping surfaces of such places as the Helvellyn Dodds there are patterns in the turf which present an intriguing problem. On the top of Stybarrow Dodd there is a considerable surface in which a network of tracks of finer grass treads through the coarser patches of reed. The tracks are not paths formed by human beings, but they look exactly like little pathways and they are covered with the fine grass, *Festuca ovina*. It was rather tempting to imagine that the sheep had something to do with the tracks, but despite the name of the grass I do not think they are responsible. The patches of reed (*Funcus squarrosus*) form, as it were, little beds between the pathways. They stand slightly higher than the latter and are rather broken up in surface while the tracks are smooth. I could not see that the sheep preferred the tracks, but it may well be that when quite undisturbed they prefer these pathways and thus tend to perpetuate them.[1]

On the north side of this same Dodd there are furrows and ridges in the turf which run down the principal slope and give the appearance of an irregularly ploughed field which has become turfed over. The ridges stand 4 inches higher than the furrows, which are about 1 yard apart. There is quite enough slope here to produce stone stripes, and at first I thought it was a case of fossil stripes. But, on digging into the ground, very little stone of any kind at all was found in the top soil. In one place there was $8\frac{1}{2}$ inches of good grey-black mould on the ridge and $4\frac{1}{2}$ inches in the furrow. Another cutting gave 6 inches for both places. Below the grey-black mould came 6 inches of yellowish-brown clayey and gravelly stuff, but the demarcation between the two was very sharp. Evidently the gravel was disintegrated rock from the rock surface below, but the latter was not reached. The ridges are more subject to frost degradation of the turf than the furrows where the turf is quite continuous, and they are probably more affected by frost heaving than the compacter furrows.

On the east slope of Stybarrow Dodd there is a patch where the frost-affected patches and the little tracks have arranged themselves in a roughly rectangular fashion, forming an irregular chessboard pattern, with one set of tracks running downhill and the other set along the contours. It seems reasonable to suppose that these vegetation patterns may depend partly on the variety of soil produced *in situ* and that the latter may depend largely on the frost heaving caused by the formation of needle ice. One more observation may be made on the degradation of the turf in these elevated parts. Very often the surviving portions of turf take the form of little craters of vegetation lying upon a surrounding mass of gravel from which the rest of the vegetation

[1] See also G. Rempp and J. P. Rothé: "Sur certaines formations du sol dans les Hautes Vosges. Sentiers de vaches et réseaux de buttes," *Bulletin* du Service de la Carte Géologique d'Alsace et de Lorraine, Tome 2, Fascicule 3, 1935. In the Lake District our catalogue of plants on the fell tops is very limited indeed, but the problem may be analogous.

has disappeared. The interior of the crater is also devoid of vegetation and is formed of gravelly soil.

Stabilized stripes

Wherever stone stripes exist there is a good deal of downhill movement in which creep, frost, and possibly solifluction take a part. At the same time vegetation is trying to regain possession of areas that it has temporarily lost. This effort may be sufficient to take possession of the parts where the surface covering is of small gravel, but it may not be sufficient to cover the larger stones of the coarse stripes. In this way we get cases of striped areas in which descending lines of stones are separated by strips of turf which are of a roughly regular width. Such an arrangement can be seen on the south slope of Swirrel Edge near the track up from Red Tarn to Helvellyn. Should these lines of larger stones be covered in time with vegetation, then we shall have a case of stabilized fossil stripes buried out of sight and only to be detected by careful examination of slight surface differences of level. It may be in this way that the turf stripes previously mentioned have come into existence. But if so, they must be very old or else the degradation of fragments of stone beneath a turf covering must proceed quickly.

Gliders or gliding blocks

One of the most interesting phenomena on the summit land is the presence of gliding blocks. Only those blocks are included in this title which come downhill by another agency than gravity coupled with sapping and mining of water. The gliders only occur on the upper parts of the fells above 1500 feet O.D. or thereabouts, and the cause of their motion is frost and its consequences. The symptoms are a roll of turf pushed up in front of the bottom end of the block and a furrow behind the block running a few yards up the slope. But the most constant feature is the orientation of the block lengthwise along its own furrow, *i.e.* down the line of principal slope. They form our Lakeland representatives of Högbom's "gleitende Blöcke."[1] They can be found on almost every fell possessing the requisite height and slope and of which the surface has the necessary amount of small earthy material to form a suitable soil-flow mixture.

Dr. Hollingworth has called attention to a phenomenon which he has noticed on the Skiddaw Fells and which he refers to under the title of "Mud-flows or slips."[2] These arrangements consist of "elongated grooves or channels, a few yards long and a foot or so wide, that have been excavated in the superficial layers on the slope. At the lower end of each such channel a fan or cone of débris is usually found." Now this exactly parallels the case of the gliding blocks above described except that in the case of the Ullswater fells the block is the originator of the movement and we do not seem to get the channel without the block. It is quite easy to understand why such a difference should exist between the two areas. The fells around here are of Borrowdale rock and despite all its varieties of texture it consists of an intractable material whereas the Skiddaw Slate is provided with innumerable little

[1] B. Högbom, "Über die geologische Bedeutung des Frostes," p. 350.
[2] S. E. Hollingworth, *loc. cit.*, p. 174.

Disintegrating turf and descending waste, Helvellyn

Frost degraded turf, near Raise

Stone lines, Catstycam

Cleavage weathering and soliflucted scree, Hart Crag

Soliflucted scree, Scrubby Crag

Solifluction garland, Nethermost

divisional planes between its constituent particles and rapidly falls to pieces under the attack of weathering forces. The result is a greater amount of fine material for soil-flow movements. But in the Borrowdale rock area it requires the added weight of the block to initiate the motion.

This downhill movement of blocks, suitably situated, must have been going on ever since the ice left the tops of these fells, and in the long run it must have had a very considerable part in freeing the summit lands from erratics. On the west side of Helvellyn about a couple of hundred feet below the Shelter a great number of these blocks are found, and at one time they may have been considerably nearer the summit. Many of these blocks may not have been erratics. On the other hand, if some are erratics, they were probably much nearer the top of the fell.

Explanation of terraces and gliders

In the preceding sections the cause of the terraces and the gliders has been attributed to solifluction. Several visits to the fell tops after a frost and when the thaw has just set in have shown that the whole surface of places where stone stripes and degraded turf occur is a patchy mass of thick sludge. The little hollows are waterlogged basins of thick soupy stuff. Down below the surface the ground is still frozen. I imagine that it is when conditions are like this that the movements take place which produce terraces and gliding blocks. In other words it seems that the explanation of these phenomena is the presence of a temporary "tjäle," if one may use such a self-contradictory phrase. But the stone and turf stripes present the most intriguing problem, and it may well seem foolhardy to venture on any suggestion. The lines of stones or (in the case of the Arctic polygons) these circumferences of stones have tended to be regarded as the most noticeable factor, but possibly the lines of finer material and the polygon centres of finer material may be the chief cause of the phenomenon. If these polygon centres (or descending lines of finer material) are regarded as areas of concentration of the finer material there seem to be some facts which tend to bear this out. We know that as the frost penetrates the ground it can cause the growth of needle ice by the addition of ice crystals at the lower end of the already formed ice prism. This added moisture is sucked in from lower or surrounding areas, and in this movement towards its point of ice-fixation it may carry along with it tiny particles of matter. Such particles are certainly to be found bedded in the needle ice which one finds standing above or near the surface. Any assemblage of small particles may thus become a focus of collection, and the operation may be what Huxley and Odell have called "a self-reinforcing process."

In an experiment described in the paper on stone stripes referred to above it was found that the hollows for the coarse stripes seemed to be developed by some process of trial and error. The same thing may apply to the development of the polygon centres. Those which are unnecessary under the given conditions of frost, moisture, and soil texture would be suppressed by other more necessary and more vigorous centres.

In any case the stone stripes and the turf stripes seem to be one and the same problem although the turf stripes may possibly be a fossil condition.

If then the lines of finer material of the stone stripes and the ridges of the turf stripes are regarded as the counterpart of the polygon centres of the Arctic phenomenon, one may be tempted to look on all these as the result of the concentration of fine soil particles effected under the surface by the frost while the latter is gradually pushing its way lower and lower into the ground.

Two more frost phenomena

Stones lying in damp earthy surroundings become "frozen out" after a sharp frost at any elevation. There appears a small cleft which completely surrounds the stone and separates its upper surface from the earth. Possibly the rim of earthy matter is invaded by the frost before the stone has ceased to draw warmth from below owing to its better conductivity. If so, this rim will stiffen up and, having to expand, it will retreat all round from the stone. Exposed edges of turf seem to be particularly open to the first attack of frost. Högbom shows a picture of such an "ausgefrorener Stein" from the Riesengebirge, and discusses the cause of the phenomenon.[1] Another occurrence which he mentions as common in higher latitudes is the presence in damp earthy surroundings of big blocks of stone enclosed by a channel or tiny moat in which water may stand. This phenomenon is quite rare in this area, although I have seen two cases, one on the fells near Randerside and the other on the spur between Ruthwaite and Nethermost Coves and both about 1500 or 1800 feet O.D.

Soliflucted scree

Along the summit line from Helvellyn through Fairfield to Red Screes and in similar places, there may be found considerable spreads of scree lying at a less angle than the angle of repose for ordinary scree. They may have the remaining solid rock still standing at their crest or the rock may have been entirely disintegrated by frost. These are expanses of débris which have moved into position partly at least through the help of solifluction. Some of the largest look like great tongues of débris pointing downhill. Such a process has enabled the disintegrated rocks to be carried away from the mother rock much more quickly than would have been the case without this frost effect. In consequence the weathering effect has been greater on the rock surface in so far as the latter has been kept free and open to the continued attack. Tarn Crag, Hart Crag, Scrubby Crag, and Swirrel Edge all show this effect, and there is a particularly noticeable wave of such débris on the south-west face of Nethermost Pike.

Lake-levels

The level of Ullswater was given by the Ordnance Survey on 12 July 1894 as 475·5 feet. Near Ormathwaite barn on the north shore of Glencoin Bay there is a fairly well-marked shelf or old shore-line at about 600 feet O.D. In the Glenridding Valley at Tenterhow Farm, standing at 590 feet O.D., there is the only well-marked ancient delta of this area. These facts show that at one time the lake must have stood about 600 feet O.D. In the same

[1] B. Högbom, "Uber die geologische Bedeutung des Frostes," p. 302.

valley at Rattlebeck there is a striking section with the following layers from bottom upwards: (1) bottom boulder clay; (2) stratified delta deposit; (3) upper boulder clay. This suggests that after the lower boulder clay was deposited climatic conditions improved and the lake stood about 600 feet O.D. Then further glaciation took place either in the shape of a renewal of the ice or merely a re-advance. Later still with the water again standing about 600 feet O.D. the Tenterhow Delta was formed.

In the third or lowest reach of the lake there are deposits of sand and gravel which would point to a lake-level about 20 feet higher than the present, while around Patterdale much of the alluvial land seems to have been formed while the water stood about 8 feet higher than to-day.

About half a mile below Pooley Bridge there is an old gravel pit on the right bank of the Eamont. This pit shows a considerable depth of gravel with traces of bedded clay which must have been laid down under water. The cutting down of an obstruction here would account for the smaller downward variations mentioned above. But what held up the lake at 600 feet O.D. is not evident.

In the course of these observations, I have on several occasions had the advantage of making excursions in the company of Dr. S. E. Hollingworth and Mr. J. J. Hartley.

CAUSES OF THE FLUCTUATIONS IN LEVEL OF LAKE OSTROVO, WEST MACEDONIA

MARGARET HASLUCK

IN an earlier paper (*Geogr. J.* 87 (1936) 338–47) I described the prolonged, irregular rises alternating with prolonged, irregular falls which, since the beginning of the nineteenth century, have taken place in the level of Lake Ostrovo in West Macedonia. In a second paper (*Geogr. J.* 88 (1936) 448–56), working backwards through early Turkish, Byzantine, Roman, and prehistoric times, I showed that in the middle ages the lake lay much lower than nowadays, but much higher than in the Roman and prehistoric periods; as it rose to its mediaeval level, it overwhelmed the ancient city on and near the islet between Sut Burun and Ostrovo village, and in its modern rise it ruined the Turkish mosque on the island near Ostrovo and the Christian monastery at Pateli. My object in the present paper is to explain why these various fluctuations in its level have taken place. These explanations make no claim to be more than suggestions; perhaps even draining the lake could hardly supply a definite solution of its mysteries.

The body of water involved in the present inquiry is very considerable, as is clear from the following figures [1]:

Catchment area	1590 sq. km.
Rainfall	800 mm. per year
Run-off	30 per cent.
Drainage into lake	=12·1 cu. m. per sec.
Evaporation	say 2 mm. per day
	=1·85 cu. m. per sec.
Increase in total volume	650,000,000 cu. m. in 36 years
	=0·6 cu. m. per sec.
Subterranean inflow	say *nil*
Subterranean outflow	=12·1−(1·85+0·6)
	=9·65 cu. m. per sec.

Edmund Naumann [2] was the first to put forward an explanation of the modern fluctuations. Writing in 1893 before any scientific records had been kept, he deduced from literary evidence that Lake Ostrovo passed through periods of rise in 1801, 1836, 1858–61, 1875, and 1887. These periods in his view corresponded with the upward movements of the inland Armenian lakes which reached their periodical maxima in 1810, 1840–50, and 1876–80. So he concluded that, like the Armenian lakes, Ostrovo was a good illustration of Brückner's rain-cycle. But his conclusion is not satisfactory. At best the comparison between the dates of Ostrovo and the Armenian lakes is somewhat forced, and the intervals between Ostrovo's periods of rise are not the 34·8+0·7 years required by Brückner's rain-cycle. Moreover the dates which Naumann gives for Ostrovo are open to question. As shown in my previous paper

[1] These figures were kindly given me by Mr. B. W. Huntsman, an Englishman employed on irrigation work near Salonica by the Foundation Company of New York.

[2] E. Naumann, 'Macedonien,' pp. 23–4.

(*Geogr. J.* 87 (1936) 340–6), where new literary evidence was produced and full use made of the scientific records not available to Naumann, during the hundred years which he reviewed the lake passed through, not three periods of rise like the Armenian lakes, but only one, that culminating in 1858–62. The connection between Ostrovo and Brückner's rain-cycle seems therefore untenable.

This conclusion had already been reached by Professor Kassner,[1] but for different reasons, for he accepted with slight modifications [2] Naumann's dating of the periods of rise of Lake Ostrovo. Professor Kassner compiled from scattered year-books records of the rainfall at Salonica and Monastir, the two towns between which the lake lies, and finding no relation between lake-level and rainfall, decided that no connection existed between the fluctuations of Lake Ostrovo and Brückner's rain-cycle. The disparity between lake-level and rainfall is indeed astonishing. For instance, the records at Monastir,[3] where the climate closely resembles that of Ostrovo, provide the following comparison:

	1900	1901	1902
Average rainfall	869 mm.	805 mm.	594 mm.
Average lake-level [4]	526·87 m.	527·40 m.	528·99 m.

Thus in 1900, a very wet year, Lake Ostrovo was lower than in 1902, a very dry year. When lake-level and rainfall are compared month by month, the same disparity appears. In March and April more rain falls and more snow melts annually in West Macedonia than in January and February; yet in 13 out of the 39 years covered by the published graph of the lake's fluctuations,[5] the lake was lower in the two wetter months. Furthermore, in this region November is always very wet and August very dry; yet in 36 out of these 39 years the lake stood higher in the dryer month.

It remains, then, as Professor Kassner has said,[6] to seek the cause of the lake's fluctuations—both ancient and modern—in the underground channels (*katavothrai*) which are generally presumed, in the absence of an overground outlet, to drain off the surplus water. Local peasants say that there is only one such channel, but they can hardly be right. It will be remembered that the average subterranean outflow from the lake has been calculated at the considerable figure of 9·65 cubic metres per second.[7] Of this the springs of Kourada, believed to be the lower end of the katavothra, pour into the River Voda approximately 4 cubic metres per second. The rest of the water, altogether 5·65 cubic metres per second, must go somewhere else,

[1] "Die Seespiegelschwankungen des Ostrowsees in Makedonien," in *Gerlands Beiträge zur Geophysik*, XXXV, Heft 3/4, 1932, pp. 367–69.

[2] *Ibid.*, p. 362.

[3] *Ibid.*, p. 368.

[4] *Ibid.*, p. 364.

[5] *Geogr. J.* 87 (1936) 339.

[6] *Op. cit.*, p. 369.

[7] The figure probably errs on the side of understatement, as in this region the subterranean inflow can hardly be *nil* as given in the table. The adjacent marsh of Sari Giöl, which receives the drainage of the western face of Mount Vermion, has no overground outlet, and fluctuates in level; it is locally supposed to drain underground to Lake Ostrovo.

again by underground channels. It is conjectured that 4 cubic metres are taken by the falls of Niaoussa, perched high above the plain of Salonica on the eastern shoulder of Mount Vermion, and that the remainder issues in minor springs. If this conjecture is correct, the springs of Kourada and Niaoussa, lying respectively due east and south-south-east of Lake Ostrovo and a long way apart, can hardly be fed from the same katavothra. The peasants of Ostrovo place the one katavothra which they acknowledge slightly south of the hamlet of Begnia, some 250 metres from the shore, which is here singularly steep both above and below water.[1] Whether they are repeating a genuine folk-tradition or merely guessing, they are in this case probably right. For as shown on the map [2] the spot they indicate is near the deepest, and therefore a very old, part of the lake.

To understand how conditions in the katavothrai may affect the lake-level, it is necessary to consider the nature of katavothrai in general. As already stated, these underground watercourses are common in Greece in limestone areas, such as is that of Ostrovo. They occur especially where a plain is so closely ringed by mountains that the water pouring down into it cannot escape above ground. Solid though the rock of these mountains may seem, it is in reality seamed, both above and below ground, with innumerable fissures, varying in size from mere rifts to chasms capable of engulfing a river.[3] A good example of such a water-channel above ground exists at Ostrovo itself, found in 1916 by the French immediately north of the village as they blasted away an apparently solid rock in preparation for relaying the railway line at a higher level. The cavern was large enough for a woman to enter with her pitcher, and was then full enough to supply the whole village with drinking water. After dropping sheer for about 2 metres, it turned towards the lake and disappeared from sight. Its connection with the lake seems clear, for in 1923, when the lake-level began to fall, the water began to sink. By 1933 it was empty and the villagers once more drew their drinking-water from the lake, but in the autumn of 1934, so far as I could see into its twisted depths, its sides were still moist enough to keep a few ferns alive.

Underground channels are best studied in the Copais area of Boeotia, Southern Greece. This area, formerly occupied by an immense lake measuring 380 sq. km.,[4] and comparable to Ostrovo in that its only outlets were evaporation and katavothrai, has lately been drained. Since the water was drawn off, the mouths of twenty-five large katavothrai and innumerable smaller outlets have appeared in the sides of the surrounding hills, and in at least six cases the passage behind the entrance is large enough to be explored for a considerable distance, even by a person walking upright.[5] On walking or crawling through

[1] A. Struck, in *Globus*, vol. 83, no. 14, p. 240.

[2] *Geogr. J.* 88 (1936) 450.

[3] *Cf.* Sir J. G. Frazer's 'Commentary on Pausanias,' vol. v, p. 110.

[4] *Ἑλλάς, Ὁδηγὸς Ταξειδιώτου*, p. 185.

[5] Students are given every facility by the officials of the Lake Copais Company (London), who reside at Haliartos on the western shore of the former lake. My own thanks for such help are due in particular to Mr. G. L. Bailey, C.B.E., the General Manager, and Mr. H. McElderry, the Agricultural Manager. I am even more indebted to Mr. R. S. Cole, formerly engineer to the company, who supplied me with most of the material from which I have compiled this account.

the mouth of a typical katavothrai at Copais one finds first a considerable cave, and then a long passage of markedly irregular formation, which contracts till it ends in a series of more or less tiny cracks in the rock. The floor of both cave and passage slopes downwards with surprising gentleness. For with a few exceptions, such as the overground channel at Ostrovo already mentioned and the underground channels of Lake Pheneos in Arcadia and Lake Petersko in Macedonia, Greek katavothrai differ from the pot-holes of Derbyshire by pursuing a nearly horizontal course. Whereas the pot-holes have vertical shafts more than 100 feet deep, the Grand Katavothra, believed to be the steepest of all those at Copais, has over a distance of 6 km. an average gradient of only 14 m. per km. Since the depth at which the katavothrai of Ostrovo lie is not known, their gradient cannot be precisely calculated. But taking the lake-level of 528 m. given on the Austro-Hungarian staff-map, it appears that the katavothra to Kourada has over a distance of 8 km. an average gradient of 6 m. per km. and that to Niaoussa one of almost 9 m. per km. over a distance of 23 km.

Since the length for which the katavothrai of Copais may be explored is limited, their capacity cannot be estimated except by external examination and general inference. Thus, at the Stroviki katavothra, the remains of an old mill, once driven by water running into the cave from the lake, show that here the flow of water must have been considerable and for a long period fairly constant. The open space inside the chief katavothra at Vynia is large enough to require a couple of hours for reasonable exploration. Inside the entrance to the little-known katavothra of St. Nicolas there is a high cave about 40 metres long which leads into two passages; the first of these is nearly 300 metres long, sometimes three or four metres high, and sometimes so low that the explorer must crawl along on hands and knees; and at the end is another considerable cave, the home of countless bats whose droppings form heaps nearly a metre high. The Grand Katavothra, with an entrance cave nearly 30 m. high and more than 120 m. long, is large enough to have engulfed the Melas, one of the most remarkable rivers in the world. Starting almost full-grown from springs at Orchomenos (Skripou) at the base of Mount Parnassos, it pursued a sinuous course across the plain in a canal-like bed and, till diverted by the draining of the lake, disappeared into the Grand Katavothra; according to Mr. Cole the springs, whose volume is almost constant in summer and in winter, pour out about three cubic metres of water per second. As for Ostrovo, since the springs at both Kourada and Niaoussa discharge four cubic metres of water per second, it may be that the katavothrai feeding them are even larger than the Grand Katavothra of Copais: immediately behind them there must certainly be very large passages.

We now come to the connection between katavothrai and fluctuations in lake-level at Ostrovo. These fluctuations include two extreme rises, one in ancient times and the other in the nineteenth century. At its new level in modern times the lake has shown relative steadiness on occasion, several abrupt rises and one abrupt fall of importance, several slow, persistent, considerable falls, and many little rises alternating with no less frequent little falls. For all these various phenomena the explanation sought must account. To begin with, the level of any lake drained by katavothrai is apt to vary, not

only because the quantity of water sent down the channels differs with the seasons, but also because the capacity of the channels, and consequently their outflow, is constantly changing. Katavothrai are always liable to be alternately blocked and unblocked. They may be blocked by the slow silting up of the passages, which are so irregular that they offer every facility for the lodgment of all sorts of débris—mud, stones, logs, vegetable matter, and the like.[1] A picturesque result of this disability is that, however muddy the water that enters, the spring at the exit, as at Kourada, is always crystal-clear, the mud having been held up in the passages; to this rule the Grand Katavothra at Copais, reported by good witnesses to discharge water nearly as muddy as that which it receives, seems the only exception known in the Greek area. Where the passages take the form of siphons, and of these there are several examples at Copais (we do not know about Ostrovo), silting up is particularly easy. But complete blocking of a large katavothra by this agency alone is so rare that at Copais there is only one example, the Great Kasnechi katavothra. Partial blocking on the other hand is so common that every katavothra at Copais shows signs of it. Whenever it takes place, the level of the lake drained by the katavothra necessarily rises. Since the amount of débris causing the block is hardly likely to be the same twice running, the resultant rises in the lake-level vary in degree. Partial blocking by mud and vegetable débris is generally followed by unblocking. For in matters of this kind events are seldom clear-cut, and no block is likely to be absolute. Water probably continues to seep through the block and in time its pressure tends to blow out, partially or wholly, the débris and mud, so clearing the passage and permitting the lake-level to fall.[2] At the same time, the solvent action of water on limestone being considerable, as is well seen on the pock-marked rocks littering any Greek mountain-side, the water tends very slowly to enlarge the openings left, or even to pierce new openings by dissolving away the adjacent rock. In these ways the outflow might even come gradually to be more or less what it had been before the block took place. It is therefore to partial blocking of this nature in one or other of the main katavothrai draining Lake Ostrovo that I should ascribe the majority of the minor and irregular rises in the modern lake-level. To subsequent unblocking by water pressure and solution I should attribute the minor falls, both abrupt and slow.

It would seem from Copais that in most large katavothrai silting is only a secondary cause of blocking; the main cause is falls of rock helped by subsequent silting. Rock may fall for two reasons. The roof of the passage may be so weakened by water erosion that it falls in of itself, a process which has been

[1] *Cf.* Dr. A. Philippson, "Der Kopais-See," in *Zeitsch. der Gesell. f. Erdkunde*, Band xxix, 1894, no. 1, pp. 1–2.

[2] The most notable example of such blocking and unblocking by mud and vegetable débris seems to be Lake Pheneos in Arcadia, Southern Greece. Mountain-locked and drained by two large katavothrai, its area is sometimes 9 square miles, and sometimes only 1; its basin is sometimes 50 m. deep in water, and sometimes almost dry; and the River Ladon, which is fed by one of the katavothrai, is alternately a dry watercourse and a deep and raging torrent. In 1892, when the lake was high, the water at the source of the Ladon ceased to flow, reputedly after a violent earthquake; after three hours the spring began to flow a little, and three days later there was a loud explosion just before the water burst forth in immense volume (Frazer, *op. cit.* iv, pp. 262–3).

explained as follows. In katavothrai such as those of Copais the strata are not horizontal, but invariably inclined to the horizontal at an angle of about 70 degrees; it has even been possible to find small katavothrai by the inclination of the rock. It seems therefore that before a katavothra was formed there must have been some preliminary folding of the strata due to pressure, so that they were considerably shaken up and shattered; this is confirmed by examination of a katavothra at Copais, where the ends of the rock are not smooth as they would be if eaten through by water, but ragged. At first, when a katavothra was new, the aperture would be in steeper strata. But as the lake-bed rose, owing to the influx of débris and silt, as there are signs that the Copais basin has risen, the bed of the katavothra would rise with it.[1] Then the rocks overhead would be eaten away, the strata grow more nearly horizontal, and the roof more and more unsafe, so that its caving in would be only a matter of time. At Copais such a fall is perhaps illustrated by the large slab of inclined rock which has fallen bodily in one of the Vynia katavothrai; presumably the passage went under it before it fell. Such falls of rock are generally small, and they may occur at any time. When they do, there can be no question, as with vegetable débris, of blowing out the plug. But the block not being absolute, water would seep through and gradually enlarge the interstices, and at the same time its solvent power on the limestone would enlarge other channels, till it escaped more freely and caused the lake-level to fall. It is therefore to such falls of rock, especially after they have been somewhat silted up, that I should ascribe such important rises in the level of Lake Ostrovo as took place abruptly in 1915 and 1919. To subsequent enlargement by water action of the interstices in the block or of other channels I should ascribe the slow, prolonged falls which followed these rises.

In the second place the roof of a katavothra may be shaken down by one of the many earthquakes from which Greece suffers. As Strabo [2] tells us—with more or less probability—that this happened more than once at Copais, the big block inside the Grand Katavothra may be an example.[3] A hundred metres inside the entrance there is a skylight which lets daylight into the cavern; 20 metres farther in lie the rocks that fell from the roof to open this skylight. Heaped in a confused mass 15 m. high, 46 m. long, and containing at a rough estimate 20,000 cubic metres of rock, these rocks have almost blocked the passage; only a little water can now escape through the gaps between them and by the narrow opening left unobstructed on one side. They evidently fell away along the cleavage plane, leaving a large flat inclined rock face hanging almost in mid air. A second block may exist farther in, for

[1] This has certainly happened at the Grand Katavothra of Copais, for well inside the entrance Mr. Cole dug 3 m. down, and found not the solid bottom, but only rocks and clay. Some way, too, before the entrance to the katavothra is reached, pits have opened since the modern draining of the lake; through these a moderate amount of water escapes, by paths as yet undetermined; after excavating to a depth of nearly 3 m., Mr. Cole found, not hard rock with a fissure as expected, but only silt, clay, and stones.

[2] ix, p. 406.

[3] This is only a possibility, not a certainty. The roof of the katavothra is so thin at this point that, by the process described in the preceding paragraph, it may have caved in of itself.

on tracing the line of the cavern on the ground outside one comes to a depression in the mountain-side like a quarry; when a shaft was sunk between this depression and the sky-light, sand was discovered, presumably brought there by water. This suggests that the depression may lie in the line of the katavothra; if so, it may be due to the falling in of earth and stones. At the entrance also rocks must have fallen, for on both sides, and outside as well as inside, there are stacked myriads of small, neat stones in dry walls: one of the puzzles of Copais. The most plausible explanation is that the builders wished to clear away rock blocking the entrance, broke it up for better building, and stacked the pieces as near as possible to the fall.[1] As there are no signs that any attempt was ever made to remove the skylight block, it may have been subsequent to that at the mouth.

Some such catastrophe as these falls of rock was—possibly after an earthquake—responsible for the formation of the lake. For in very ancient times Lake Copais was, like part of Lake Ostrovo, dry land occupied by "cities, tilled fields, and paved roads," such as Orchomenos,[2] the fields whose rich crops made it one of the first cities in Greece, and the embanked road leading to Mount Ptoon from the middle of the lake, where stands the imposing fortress of Mycenean type now called Gla. But the plain was kept dry only by the remarkable engineering skill of the "people of Orchomenos," [3] who were perhaps the prehistoric Minyans. They built a system of canals, not discovered in their entirety until the modern draining, to lead the water, following the lie of the land, from west to east; since these canals touched as many katavothrai as possible on the way, their builders were evidently alive to the uncertainty of katavothrai in general and wished to ease the strain on the great outlets at the east end, the Grand Katavothra and its neighbour at Vynia. They also seem to have understood the dangers of silting, for traces of settling ponds have been found before the Vistrica katavothra and also before No. 14. But the blocking of a katavothra—we are not told which [4]—made all their endeavours vain and turned the fertile plain into a swampy lake. As the ancients told the story,[5] when Herakles as champion of Thebes was at war with the people of Orchomenos, he blocked a katavothra to flood the plain and so to deprive the enemy of the use of the cavalry in which lay their chief strength. The demi-god may however only have personified a great earthquake.[6] Whether that is so or not, the damage he did could not be repaired by natural agencies, and until the resources of modern science came into play, the lake remained in being and the plain was but a memory.

[1] Similar stacks are found in the katavothra of St. Nicolas. This work is sometimes attributed to the engineer Krates who in the fourth century B.C. made an abortive attempt at Alexander the Great's behest to clear the passage (Frazer, 'Commentary on Pausanias,' vol. v, p. 118). I was informed locally that King Otho of Greece was responsible. Sir James Frazer (*loc. cit.*) thought the walls in the Grand Katavothra modern.

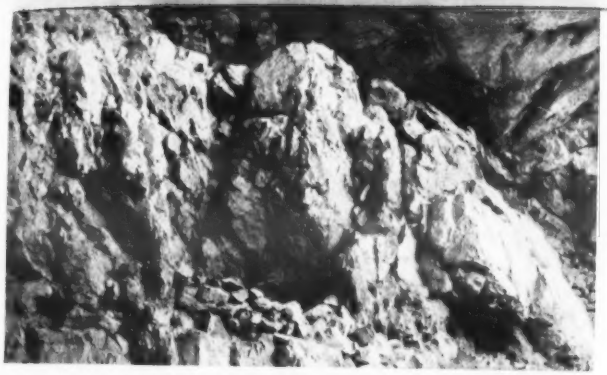
[2] Also the nameless village of which traces were found by the modern engineers south-east of Stroviki in one of the lowest portions of the lake-bed.

[3] Strabo, ix, p. 415.

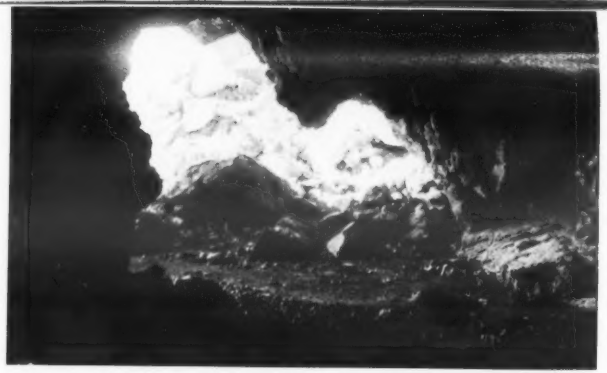
[4] Philippson (*op. cit.*, pp. 47–8) and Frazer (*op. cit.*, vol. v, p. 194) both think it may have been the Spitia katavothra.

[5] Polyaenus, i, 3, 5; *cf.* Diodorus, iv, 18, 7.

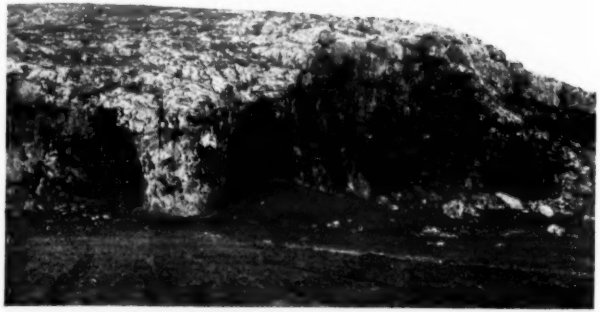
[6] *Cf.* Frazer, *op. cit.*, vol. v, p. 194.



Fissures in rock outside Grand Katavothra, Copais



Block inside Grand Katavothra, Copais



Mouths of katavothrai in hillside at Copais

Skylight in Grand Katavothra from above

Depression suggesting collapse of roof of Grand Katavothra, Copais

Derelict katavothra at Petersko

Katavothra and threshold of former mill, Petersko

It is to a great fall of rock after a severe earthquake that I should attribute the enormous permanent rise in the average level of Lake Ostrovo after Roman times. For we have a legend which enshrines the memory of a catastrophe sudden and serious enough to have been the work of an earthquake, and at the required date a terrible earthquake is known to have occurred. Of the legend I have already given an abbreviated version,[1] but think it now worth while to summarize the fuller version told to the German archaeologist, Adolf Struck.[2] Once, says this variant, there was no lake, but only a deep and beautiful valley with a cave near the middle. Two streams, one coming from the south and the other from the east, met in this cave and disappeared together into the bowels of the earth, flowing towards the east. A number of villages, whose names have been forgotten, were scattered up and down the valley; the most important one, called Kuchuk Stambul (Turkish for "Little Constantinople") in allusion to its magnificence, stood on a hill and contained a thousand houses. The "Bulgars" pastured immense flocks of sheep along the sides of the valley, especially towards the north-west. But the place was cursed by a girl who, outraged by her stepfather, drowned herself in one of the streams. One spring, at shearing time, torrential rain began to fall. Soon the two streams, coming down in high flood, overflowed their banks and, carrying all before them—sheep, shepherds, piles of wool, trees, rocks—they blocked the subterranean outlet. The rising water of the lake swamped the villages, including the lower part of Kuchuk Stambul. The villagers took refuge on top of the hill which stood out above the waters like an island. At last some made rafts and escaped to the mainland, where they founded on the west bank of the new lake a village called Begnia from the Slav word for "fugitive." The heavy rain continued, till it became clear that the subterranean outlet was blocked for good and that the lake would never subside to its old level. The last refugees fled from the hill-top, and, settling on the island-peninsula near Ostrovo village, commemorated their recent adventures on the hill-top by calling their new settlement "Ostrovo," *i.e.* island.

If the story is not true, it deserves to be: some fact is mingled with the fiction. Without being unduly imaginative we may recognize the cave as the entrance to the katavothra draining the lake in classical times, and the two streams as the Nalbanköi and the Chegan; the direction in which they must still flow underground to the springs of Kourada is correctly given. In Struck's time (about 1900), since Macedonia still belonged to Turkey, Macedonians flattered towns by comparing them with the Turkish capital. The "Bulgars" very fairly represent to the Turkish narrator the pre-Turkish heroes of the story, although it is probable that the Bulgars did not come till after the catastrophe. The slopes of the valley towards the north-west, being exceedingly steep, would more likely be pasture than arable land. The girl's curse is a fairy-tale of a well-known type. Sheep may easily be drowned wholesale by the sudden flooding of a Balkan river but hardly in the neighbourhood of Ostrovo as it is to-day, so that, if the valley had not once been different, a native of the village could not well have thought of this incident. Kuchuk Stambul and its hill seem to be the islet near Sut Burun and the ancient settlement once

[1] *Geogr. J.* 87 (1936) 345.

[2] See *Globus*, vol. 83, no. 14, p. 217.

crowning it; the Serbian word *begunac* (fugitive) is near enough to Begnia for popular etymology. Until the nineteenth century the lake seems to have remained low enough to make the modern island-peninsula near Ostrovo fit for human habitation. It only remains to add that Dr. Edward Brown,[1] travelling in 1669, heard that a fall of rock had blocked the katavothra; the lake, he says, "was made by taking great stones out of the side of the Hills, whereby the subterraneous water, finding vent, over-flowed the Neighbour Plaines."

As for the earthquake which possibly caused the disastrous flood, since all the archaeological remains so far found in the drowned cities, with the doubtful exception of the ruined castle on Sut Burun, seem to be no later than the sixth or seventh century of our era, this may have been the terrible convulsion which in A.D. 518 wrought widespread havoc a little to the north of Ostrovo. Here, in the translation by Sir Arthur Evans,[2] is the description of this catastrophe left us by the Illyrian traveller, Comes Marcellinus: "In the province of Dardania 24 *Castella* (fortified towns) were ruined in a single moment by repeated shocks of earthquake. Two of these were overwhelmed, with all their habitations; four with half their buildings and inhabitants; eleven were overthrown with a loss of a third of their citizens and houses; seven more lost a quarter of their houses and population and were left deserted through fear of the neighbourhood of the ruins. Moreover, the Metropolitan city of Scupi [Skoplje] was ruined to its foundations, though without any destruction of its citizens, for they were at the time in the act of fleeing from the enemy. In one castle, in the district of Canisa, called Sarnunto, there took place an eruption, and the earth vomited forth from its inner cavities a continual burning shower on every side, like the blast from a fiery furnace." Many mountains throughout the province were rent asunder; rocks and forest trees were torn from their sockets; and, the Comes concludes, a yawning chasm "12 feet in breadth and 30 miles in extent" intercepted and entombed many of the fugitive citizens. This formidable earthquake at Skoplje, as a glance at the map shows, was certainly near enough to Ostrovo to be dangerous to any weak portion of the roof of the katavothrai. And Sir Arthur Evans [3] brings it even nearer by identifying Sarnunto, one of the *castella* destroyed, with Varnounta, an ancient town situated on the Egnatian Way near Monastir. I suggest tentatively, then, that at the close of the Roman epoch the lake rose with the disastrous suddenness of the legend, because one or more of its main katavothrai was blocked by a fall of rock caused by the earthquake of A.D. 518.

Only the extreme rise in the lake-level in the nineteenth century now remains unexplained. In this case there can hardly be any question of an earthquake. For no earthquake of any importance took place in the neighbourhood at an appropriate date,[4] and some of our documentary evidence about the rise [5] stresses its gradual character, a feature quite inconsistent with an

[1] 'Travels in Hungaria, Servia, Macedonia,' p. 45.

[2] In *Archaeologia*, vol. xlix, 1885, p. 89.

[3] *Loc. cit.*

[4] So I am kindly informed by Miss Ethel Bellamy of the University Observatory, Oxford.

[5] *E.g.* Mrs. Walker, 'Through Macedonia,' pp. 126–7; *cf.* H. F. Tozer, 'Highlands of Turkey,' i, 159.

earthquake. The rise also swelled in 1858–62 to a climax, which was followed by a fall lasting till 1900, when another rise, which culminated in 1923, set in.[1] These peculiarities probably find their explanation in the following remarks by Philippson.[2] In all lakes drained by katavothrai, he writes, "occurs a phenomenon which alters the capacity of the channels. This is the slow, but continuous, raising of the bed of the lake by the materials brought down by rivers. So every katavothra is in time covered up. When this occurs, the water still forces itself for a time into the old channel, now buried under the lake-bed, and carries with it a great quantity of loose earth. Soon the mouths of the katavothrai are completely buried, and so put for ever out of action. If the more important katavothrai of a lake are blocked in this way, the lake must rise until new katavothrai are formed at a higher level as the water dissolves away the rock and enlarges the crevices it finds in the rock. So we find great differences in the water-level extending over long periods of varying length; these consist of a marked rise in level, followed by a slight fall, and then by a long period of relative stability." I suggest then that Lake Ostrovo rose so notably in the nineteenth century because the mouths of one or more of its katavothrai were buried under débris and that it will never again fall to its mediaeval or Roman level.

What does the future hold? If my application of Philippson's remarks to its recent change of level is justified, then we may expect the lake to fluctuate within its present limits for a long period, possibly for many centuries. Then it will once more cover up the mouths of its katavothrai and, if left free from human interference, rise to a still higher level. Indeed, it may repeat its very ancient history. For geologists [3] hold that once it lay so high that it had an overground outlet, a river issuing at the south-east corner to flow across the low saddle (600 m.)[4] between the basins of Ostrovo and Vladovo, and so down the valley to Vladovo and Vodena. But katavothrai formed and drained the lake so effectually that it sank gradually to at least its Roman level. A somewhat analogous history may be discerned at Copais, where the katavothrai are the cause of the lake. Had no water escaped, the basin must have filled up in course of time and overflowed, probably to Laryma. But the katavothrai kept the water down and were the cause of keeping the lake. In the case of Ostrovo, unless conditions of food supply and motive power change radically, it is most unlikely that the overground outlet will again be allowed to function. Before it could do so, the lake must be so high that it would flood the southward plain as far as the village of Kaialar, so destroying many hundreds of acres of valuable agricultural land. The formation of such an outlet would also spell death or at least paralysis to the many factories at Vodena and Niaoussa, for it could not hope to rival the steady springs of Kourada and Niaoussa as a source of the electricity on which these factories run.

One more small point may be discussed. Five kilometres to the west of

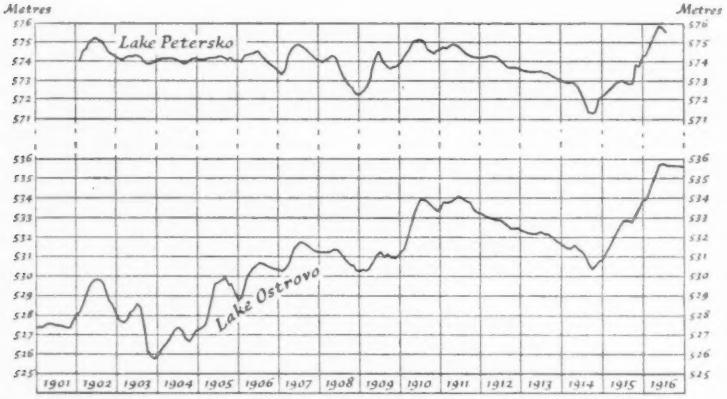
[1] *Cf.* the graph *Geogr. J.* 87 (1936) 339.

[2] *Op. cit.*, p. 2.

[3] *Cf.* A. Viquesnel, "Journal," in *Mémoires de la Société Géologique de France*, 2nd series, vol. i, pt. ii, 1846, p. 253; A. Grisebach, 'Reise durch Rumelien im Jahre 1839,' ii, 154.

[4] 'Handbook of Macedonia,' p. 228.

Lake Ostrovo, and 50 m. higher, lies the little lake called Petersko. This, too, has no overground outlet, but is drained by katavothrai and consequently fluctuates in level. There are four katavothrai, say the natives, but foreign observers have identified only two, both on the north-east shore. During my visits in 1935 and 1936 only one was working; a deep, pellucid pool lay before its mouth, into which the water hurried with a loud gurgling. At one time the water drove a flour-mill, but about 1920 the miller was declared a public enemy because he admitted only as much water as he needed for the mill and turned the rest back into the lake, so raising its level and increasing its area to the detriment of local agriculture; the accusations were the more vehement because a rival had set up an oil-driven mill in the village of Petersko. Permission was therefore obtained from the government to destroy the old mill so as to allow the water to escape unhindered. This katavothra is partially blocked, and about 1930 the Greek Refugee Commission, bent on draining the lake to get more land for the refugees from Asia Minor, blasted away the



Graph illustrating the correspondence in the fluctuations of Lakes Petersko and Ostrovo

mountain in vain in the hope of finding the block and destroying it. The second katavothra, now derelict, is in an isolated rock which thrusts forward into the lake; its mouth is about 3 m. wide and 0·5 m. high.[1] The lake fluctuates within narrow limits. About 1893 the derelict katavothra was working,[2] but in 1899 Oestreich found it 5 m. above the water; in 1897, during the Graeco-Turkish War, so I have been informed locally, the lake-bed was so dry that a Turkish army picketed its horses in it, but other informants have denied this; in 1902 the lake-level was 575·23 m., in 1908 572·26 m., in 1910 575·15 m., and in 1914 571·35 m. above the sea.[3] The Greek staff-map of 1927 marks

[1] Karl Oestreich, "Beiträge zur Geomorphologie von Makedonien," in *Abhandl. d. Geogr. Gesellsch.*, Wien, Band IV, 1902, p. 145.

[2] Oestreich, *loc. cit.*

[3] From the records of the Greek railway.

it as 4·1 m. deep in places, and in 1935 I found it only 1 m. deep and was told it was often less. Most remarkably, according to the records kept by the authorities of the Salonika–Monastir Railway (on whose observations the graph given on previous page is based) from 1902 to 1916 inclusive, its fluctuations correspond with those of Ostrovo; when the latter is high, Petersko is high, and when Ostrovo is low, Petersko also falls. The natives explain this coincidence by saying that the katavothrai of Petersko drain into Ostrovo. But, more ingeniously, it has been suggested [1] that they drain, not into Lake Ostrovo, but into one of the katavothrai of that lake which is alternately blocked and unblocked, and that they drain into this katavothra above the block; in this way when the katavothra is blocked, it dams up the outflow, not only from Ostrovo, but also from Petersko, and when the block is cleared away, the water of Petersko as well as that of Ostrovo finds free vent.[2]

DRIFT OF THE SOVIET POLAR CAMP

ON May 21 last Professor Otto Schmidt, the Director of Soviet Exploration in the Arctic, flew north from the new air base on Prince Rudolf Island with four companions piloted by Vodopyanov and landed on an ice-floe some miles from the Pole. In a wireless message summarized in *The Times* of May 24 he announced that five tents had been erected, and he anticipated that the station would drift probably towards America, but that the party of four whom he would leave there hoped to keep in constant touch through Prince Rudolf Island and other wireless stations.

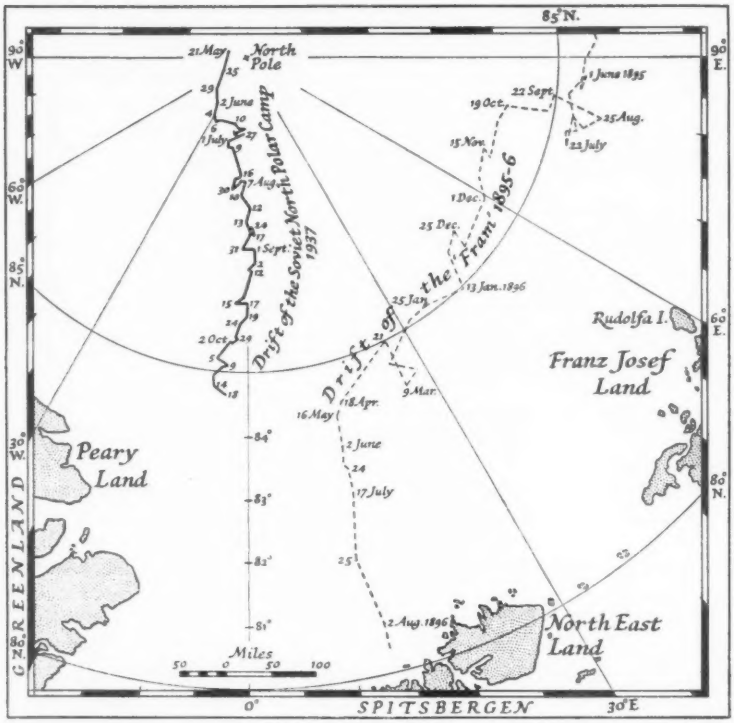
On May 25 three more large aeroplanes left Prince Rudolf Island for the Polar camp on receipt of instructions from Professor Schmidt. A machine piloted by Molokov reached it after seven hours. A second machine piloted by Alexeyev failed to locate the camp and came down at distances variously stated as 13 and 30 to 40 miles away, but soon rejoined. The third machine piloted by Mazuruk was forced down by bad weather, but made its position known to the wireless station on Dickson Island. Professor Schmidt reported that the camp was then drifting at the rate of half a mile an hour. On June 5 Mazuruk with his machine rejoined the others and by that day the four heavy aeroplanes had between them delivered sufficient equipment and provisions to last the party of four who were to be left at the camp until next summer. A message on that day said that they had drifted 100 miles in a fortnight. On June 6 Professor Schmidt with the four machines left for their base, and three of them arrived there in 5½ hours, the last being delayed a little by shortage of fuel, but rejoining shortly. The procedure of establishing by air a station with a staff of four equipped for a year's work in meteorology, hydrology, and magnetism had thus been almost entirely successful, and the

[1] By Mr. G. L. Bailey of the Lake Copais Company.

[2] I have hitherto omitted to state that before the inundation of 1858–62, according to local tradition, a pack-horse road led from Ostrovo village to Pateli along the base of Mount Kaimakchalau.

scientific party left in camp took up their tasks of soundings, transmitting weather reports, and determination of positions.

One sounding has been reported in *The Times*, in a message from its Riga correspondent dated June 8: 4290 metres about June 7, which may be compared with Amundsen's 3750 metres in lat. 87° 43′ N., long. 10° 20′ W., and Peary's 2743 no bottom at the Pole. The above message adds that the lead took 2^h 40^m to reach the bottom, and the incessant labour of all four men for six hours to get it up again, with its bottom sample of dark grey mud.



The drift of the Soviet North Polar Camp, 21 May–18 October 1937

The Times of June 8 contained an article on the objects of the expedition by Professor Otto Schmidt. By setting up a station in the vicinity of the Pole he hoped to ensure the safety of flying in the Polar region. Regular communication across the Pole would be possible only if there were a base point in the region of the Pole. He did not say "a station at the Pole," because the ice would drift all the time, but there would be no harm in this. The station would simultaneously be a stationary centre of constant observations and a travelling expedition. While laying stress upon the fact that the station would drift, he made no reference in this article to the extensive observations of

drift made during the voyage of the *Fram*, but spoke of Amundsen and his companions in the aeroplane expedition of 1925 as having made the record length of stay in the Polar basin.

During the course of the summer the weather reports of the Air Ministry began to include a statement of weather at the North Pole, derived from the wireless messages sent by the Soviet station. Inquiry at the Meteorological Office showed that each message gave also the last-determined position of the transmitting station; and Sir George Simpson very readily undertook to include the position in the daily weather report. It has therefore been possible during the last two months to read day by day the position of the Polar camp and to observe its rather rapid drift down or round about the meridian of Greenwich. In the diagram we have plotted the drift from these official weather reports published in *The Times*, or from a list kindly supplied by the Air Ministry, Meteorological Office, of positions which they had received but had not in the earlier days published; and for comparison we have shown the drift of the *Fram*, farther east but roughly parallel. Up to the middle of August the monthly drift in latitude was less than a degree: in the last two months it has been nearly a degree and a half per month, and the southward drift of the *Fram*, faster in winter than in summer, does not give any ground for believing that with the approach of winter the drift of the Polar camp will be slowed. There must therefore be some anxiety lest the camp should reach dangerously low latitudes during the dark winter months, and its position reported daily by the Air Ministry will be followed with concern.

Note.—The name of the northern island of the Franz Josef archipelago has been in English "Crown Prince Rudolf Land." In the messages from the Soviet expedition reproduced in *The Times* since May last the name is rendered "Prince Rudolph Island" and "Rudolf Island." The *Arctic Pilot*, Vol. I, 1933, gives "Rudolfa island" as the English equivalent of Soviet usage.

LOPO HOMEM'S ATLAS OF 1519

MARCEL DESTOMBES

Note.—To the *Journal* for August 1930 (76.159) and March 1931 (77.250) Mr. Edward Heawood contributed two short articles upon a previously undescribed map by Lopo Homem of 1519, the second paper being accompanied by a photograph of the map and of the inscription on the reverse. This map is the earliest extant work by a member of the Homem family, who were noted official cartographers in Portugal during the sixteenth century. It was however criticized by Signor G. Caraci as a clumsy modern forgery, chiefly on account of its geographical details and its differences from the large world-map by Lopo Homem, dated 1554, at Florence.

The writer of the following article seeks to show that the map of 1519 is a leaf from the Atlas in the Bibliothèque Nationale known as the Miller Atlas, previously attributed to Pedro and Jorge Reinel and variously ascribed to the years 1515–1520. The authenticity of this atlas has never been questioned. If the writer's conclusions are correct, not only must the Lopo Homem world-map of 1519 be accepted as genuine, but the Miller Atlas must be assigned to Lopo Homem, and not to the Reinels.—ED. *G.J.*

THE Bibliothèque Nationale, Paris, acquired in April 1897 a Portuguese Atlas, composed of four leaves and a large map, which surpasses in accuracy and in the richness of its colours all similar productions of the first half of the sixteenth century. Anonymous and undated, this document is known by the name of its former owner, Benigne-Emmanuel Miller, who in 1833 was Librarian of Manuscripts in the Bibliothèque Royale, and later librarian to the Assemblée Nationale from 1850 to 1880. Miller obtained this atlas from the Visconde de Santarem, who died in 1856, and who had bought it in 1855 from the bookseller Et. Charavay. This is all that is known of the provenance of this magnificent manuscript, the geographical nomenclature of which serves as a basis for all studies of sixteenth-century cartography.

Santarem, the first to study it, dated it as before 1529, but his conclusions, which remained in manuscript, did not appear until 1919.[1] Gabriel Marcel, Assistant Curator in the map department of the Bibliothèque Nationale, published at the time of the purchase of the Atlas his "Notes sur quelques acquisitions récentes de la section des cartes" (*C.R., Soc. de Géogr., Paris*, 1897, 385–8), in which he assigned the date 1514 to these maps. He pointed out their resemblance to the maps in the Hauptkonservatorium des Armees in Munich, amongst which there is one signed "Pedro Reinel." Then H. Harrisse studied the large map which he called "Miller No. 1," and dated it *circa* 1520–1521.

M. Denucé, Archivist of the city of Antwerp, was the first to undertake the task of tracing the author in a thesis published in 1909 by the University of Ghent.[2] Basing his conclusions on the resemblance between the

[1] Vde. de Santarem: 'Estudos de cartografia antiga,' V. 1, 225–8, Lisbon, 1919.

[2] Denucé, J.: 'Origines de la cartographie portugaise et les cartes des Reinel,' Gand, 1908; and "Magellan, la question des Moluques, etc.," *Mem. Ac. R. Belg.*, 2e sect., 4 (1911).

writing of the Miller Atlas and that of another map signed "Reinel" in the collection of Baron Ricasoli Firidolfi of Florence, he attributed the Atlas to Pedro and Jorge Reinel. As he correctly considered that the Atlas was made in Portugal, he dated it from before the departure of these cartographers for Seville about 1516–17. M. Denucé's attribution has been accepted up to the present time, and the Atlas is better known as "the Reinel Maps at Paris" than as the "Miller Atlas," the name given to it by the Bibliothèque Nationale. Dr. A. Cortesão, in his recent work on Portuguese cartography,[1] gives Jorge Reinel as the author of the Miller Atlas and of a large anonymous map at Munich, known until now either as "Kunstman IV," the name of the editor of an atlas in which the map was first reproduced, or as "Anonymous 1520," the majority of students having accepted that date, which is probably too early. Dr. Cortesão also points out, following J. de Figueiredo, that the magnificent paintings in the Miller Atlas are probably by Gregorio Lopez, who coloured the Book of Hours of King Manuel, one of the treasures of the Museu de Arte Antiga in Lisbon, which was displayed at the exhibition of Portuguese Art in Paris, 1931.

One writer alone, M. Émile Eude,[2] Attaché to the French Legation at Lisbon, supported however by MM. de la Roncière and du Bus, cast doubt upon the attribution to the Reinels, and announced that he would present a paper on the Miller Atlas at the Geographical Congress of 1928. He died a short while before the Congress however and I have been unable to find out what his conclusions were, though it seems probable that he regarded Magellan as the author.

The Miller Atlas has been reproduced, first in part by Denucé and most recently in colour, with the exception of one map (see plate) of Europe, by Kammerer in his work 'L'Abyssinie et la mer Rouge,' vol. II, pt. I.

The leaves of the Atlas have drawings on both sides, and they are now mounted in a modern album, which allows each to be examined. The central folds which divide the leaves into two parts, and their arrangement, clearly show however that these maps were formerly part of a collection measuring, when closed, 30×41 cm., the maps when open measuring 41×59 cm. If each leaf is folded and placed one on top of the other, the arrangement of the collection is—

Leaf	1.	1st verso	(Blank).
		recto (2 parts)	North-West Europe.
		2nd verso	Azores.
,,	2.	1st verso	Madagascar and East Africa.
		recto	Indian Ocean.
		2nd verso	Malaysia (West part).
,,	3.	1st verso	Malaysia (East part).
		recto	China Sea.
		2nd verso	(Blank).
,,	4.	1st verso	(Blank).
		recto	Brazil.
		2nd verso	(Blank).

[1] Cortesão, A.: 'Cartografia e cartografos portugueses,' Lisbon, 1935, I, 278–98.

[2] Eude, E.: *Bul. Sect. Géogr., Comité des trav. hist.*, Paris, 1927, xlvii; and 1928, xxxviii, lxxxvi.

The large map is inserted in the same way in the Atlas, by means of two folds, quite visible at top and bottom, which bring the dimensions to those of the other leaves.

After noting the contents of each leaf, and assuming that the atlas was intended to cover the Portuguese field of activity, I infer that two complete leaves are missing, which should be placed on either side of leaf 1. These leaves would contain:

Leaf	A.	1st verso	Title.
		recto	Mappemonde.
		2nd verso	(Blank).
,,	B.	1st verso	North-West Coast of Africa.
		recto	Central and South Africa.
		2nd verso	South Coast of Africa from 26° to 4° south.

If completed in this manner the Atlas would comprise the Portuguese dominions in six leaves. It would be possible, if required in forming an atlas, to paste the blank portions of the leaves together, that is, the second verso of leaf A to the first verso of leaf 1, and the second verso of leaf 3 to the first verso of leaf 4—the other leaves being completely occupied by maps.

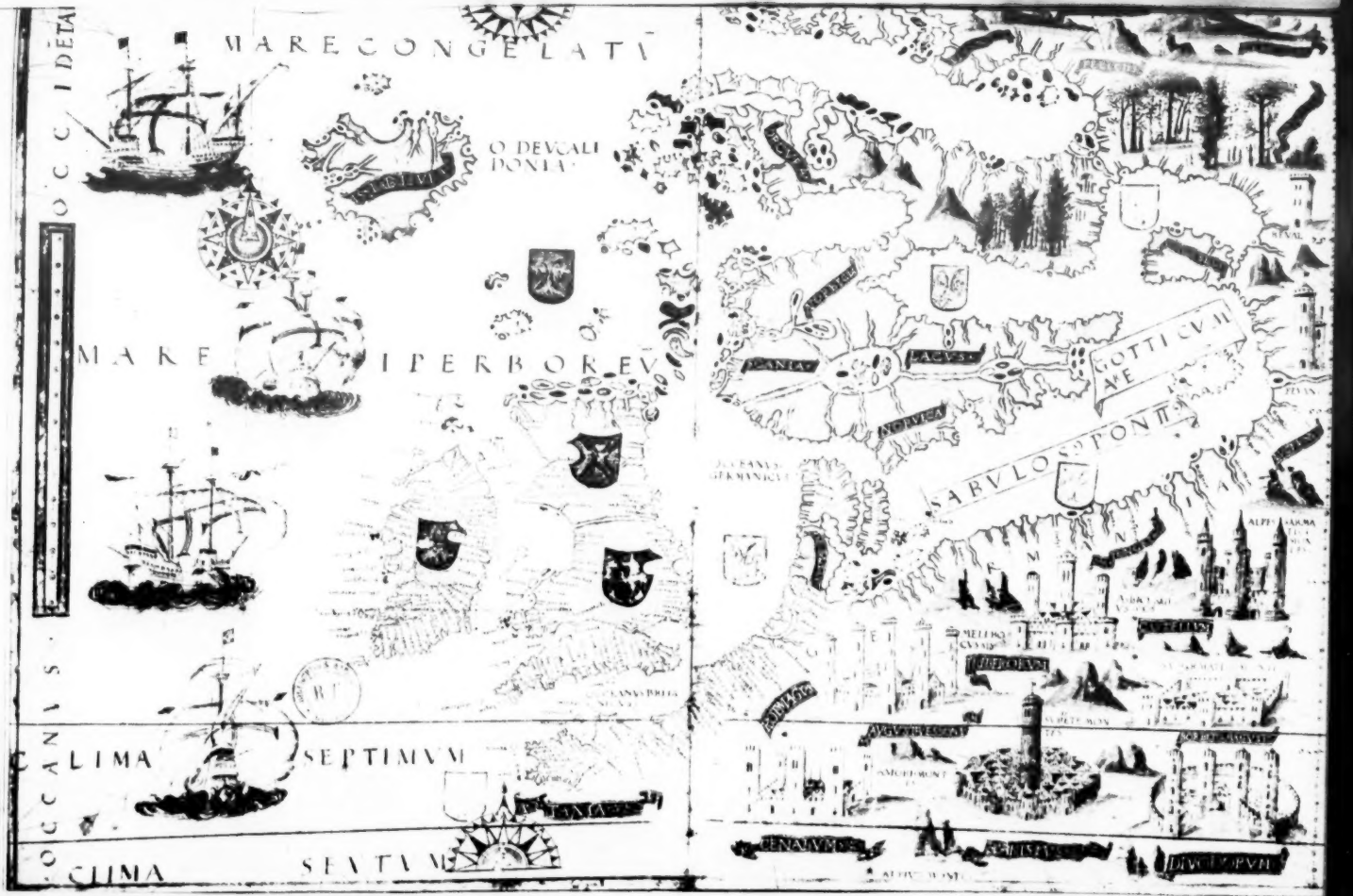
In compiling a catalogue of manuscript portolan charts of the sixteenth century, my attention was drawn to the resemblance between the Miller Atlas and the map signed "Lupus Homo," which was sold in London in 1930, and which is well known for the heated controversy to which it gave rise at that time. That map bears on the first verso the title—"Hec est universi orbis ad hanc usque diem cogniti/tabula Quam ego Lupus homo Cosmographus/ in clarissima Vlisipone civitate Anno domini nostri/Millessimo quingentessimo decimo nono Jussu/Emanuelis incliti lusitanie Regis collatis pluribus/alijs tam vetustorum qz recentiorum tabulis mag-/na industria et dilligenti labore depinxi/" On the recto, the two pages bear a round world-map enclosed in an azimuthal border graduated to 360°. Malaysia is surrounded by a multitude of islands; of the New World Brazil only is shown, joined to Asia by a land-mass south of the Atlantic and Indian Oceans, and in the North-West there is land near the border.

At the corners of the leaf, four heads, miniature chef-d'oeuvres, indicate the inter-cardinal points, the cardinal points being marked by pennants, on which can be seen traces of black letters under the gold, and by a golden sun on the East and a silver moon on the West. Below the title are painted the arms of Catherine de Medici after her widowhood in 1559. The 2nd verso is blank.

This map was declared by Sig. Caraci to be "una grossolana falsificazione moderna," and he gave the following reasons to justify his criticism[1]: The unimportance of the work represented by this map does not agree with the title. The land surrounding the map at the south and north, the pre-Magellan channel, and the fantastic representation of the Far East are anomalies incompatible on the one hand with the work of Lopo Homem, appointed in

[1] Caraci, G.: For various articles on Homem world-map, see *Riv. G. Ital.*, 37 (1930) 78–86, 138–41; 38 (1931) 98–104; 39 (1932) 81–6, 141–51; *La Bibliofilia*, 34 (1931) pt. 1.

MARE CONGELATI
DETAI



North-west Europe, from the "Miller Atlas"

By courtesy of the Bibliothèque Nationale, Paris

1517[1] to an official post relating to the Portuguese Navy, and on the other hand, with the beautiful map signed Lopo Homem, dated 1554, which is in Florence. These arguments have already been disproved by Messrs. Heawood, Cortesão[2] and Crino,[3] but as Sig. Caraci had insisted so strongly upon the great differences between the map of London and the world-map of Florence, these scholars only sought to determine whether the Homem of 1519 could also be the author of the superb map of Florence of 1554.[4]

Beyond pointing out that the writing and the spelling of the Miller Atlas are somewhat different from those of the Florence map, the signature of which so closely resembles that of Diego Homem, and also (a point which seems to have been overlooked by Professor Caraci and Professor Crino) that the date 1554 is perhaps debatable, the numeral of the "tens" having been erased and rewritten, I shall now leave aside for the moment the characteristics of authenticity in the London map and examine the resemblance it bears to the Miller Atlas—which is striking.

The Roman capitals, the shape of the China Sea and of the Moluccas, the land in the North-West, and the outline of Northern Europe are the same in the two documents—the last four characteristics are found nowhere else. The harsh green of the land is also similar to that on the first page of the Atlas; but what is more characteristic is the arrangement and the style of the scrolls bearing the inscriptions in Latin written in the same semi-gothic characters, the greyish ink of which has the same faded appearance. These inscriptions end with full-stops, followed, in some cases, by the drawing of a small feather. The framed scroll appears as though fixed to the map by two small tongues very much alike in the two documents. In the world-map of 1519, as well as in the Atlas, the border or frame has been touched up with gold, but one can easily see beneath this, which must date from the time the arms were added, two lines which are found in the frame of the scroll of the Miller Atlas. The four heads are well worthy of having been drawn by the hand that drew the miniatures in the Atlas; lastly, and this is the decisive argument, the complete leaf of Lopo Homem also measures 41×59 cm., it is folded in the middle, and can be inserted perfectly as the missing part, that is, as leaf A.

One must therefore accept as well established that the first page completes and identifies the Atlas, if it is authentic. There is no possibility of the Atlas itself being a forgery—the number and qualifications of those who have examined it forbid this hypothesis. From the arguments advanced by Sig. Caraci therefore all those based upon the alleged signs of inauthenticity common to the two must be eliminated. The expression "magna industria

[1] His functions in 1517 certainly included the construction and correction of compasses for the Royal ships, if not the drawing of charts, a task with which moreover he was charged before 1524.

[2] Cortesão, A.: "Os Homems," *O Instituto*, Coimbra, 83 (1931) 539; 84 (1932) 59, 188.

[3] Crino, S.: "Le carte da navigare conservate nel Museo degli Strumenti Antichi di Firenze, e la carta di Lopo Homem posseduta dal Duca Salviati di Migliarino," *Riv. Marittima*, Suppl., Rome, March 1932.

[4] Mr. Heawood however had shown that some of the geographical features of the Homem map have their counterpart in the Atlas ascribed to the Reinels (*Geogr. J.* 76.160; 77.252), and that Homem's representation of the Southern Atlantic resembles that of the Piri Reis chart (*Geogr. J.* 82.269).—ED. *G. J.*

et diligenti labore" can certainly be applied to the whole of the Atlas. With regard to the coat of arms of Catherine de Medici, this must have been added between the years 1559 and 1583, when the Atlas, presented to the Regent, may have confirmed her in the idea of a French Colony in Brazil or in the Antarctic, an idea which forms the famous "secret de la Reine" brought to light by M. de la Roncière in 1908 (Revue d'Histoire Diplomatique). The project for the departure of the Viceroy of "la France Antarctique" coincided with the publication of a book entitled 'Les Trois Mondes,' in which the Sr. de la Popelinière recommended the "troisième monde" for colonizing by the French, that is, neither the old nor the new world, but the southern continent. Apart from the Schöner globes, this continent may be seen as early as 1513 on the Piri Reis map in Istanbul, claimed by the author to have been compiled from Portuguese charts, and its presence on the map here discussed shows plainly the desire of Lopo Homem to reconcile Ptolemy with the modern discoveries in Africa. On the other hand, one can with difficulty accept the suggestion that the leaf of Lopo Homem's world-map could have been forged in its entirety by an owner of the Atlas before the year 1897, for the vellum has the same central fold and the same appearance of age. A mistake in the date is impossible, as it is written out in full; moreover a close examination at once establishes the complete authenticity of the signature.

As the criticisms dealing with the geographical features alone cannot withstand a comparison with the Miller Atlas, I consider that other doubtful points—the retouching with the paint-brush—are of no importance and do not in any way affect the map itself. Therefore we can accept the authenticity of the world-map of 1519, and the authorship of Lopo Homem and the date 1519 for the Miller Atlas.

The Lopo Homem Atlas of 1519 is the only geographical work which employs the degree of $16^{2}/_{3}$ leagues; all the other maps known at present, dated or undated, are made with the degrees varying from $17^{1}/_{2}$ to $18^{3}/_{4}$ leagues. If we knew that about 1518 the degrees of $16^{2}/_{3}$ leagues gave place to degrees of greater length, that peculiarity would perhaps require us to re-examine the question of the dates of anonymous maps accepted as previous to 1519, and in this case the Atlas would take the first place, with regard to date, in the list of geographical monuments purely Portuguese. However that may be, the Bibliothèque Nationale possesses the first Portuguese work both signed and dated by the official cartographer of Portugal, of whom up to the present no dated chart was known during the first half of the sixteenth century. These maps now establish with certainty the maritime knowledge of the best navigators at the time of Magellan's departure.

REVIEWS

EUROPE

LAND CLASSIFICATION IN DORSET: . . . with special reference to agricultural distributions . . . By L. ELLIS TAVENER. (The Institute of British Geographers. Publication No. 6.) *London: George Philip & Son*, 1937. 10×7 *inches;* vi+61 *pages; maps.* 7*s* 6*d*

The body of this book is made up of seventeen maps, drawn on the scale of 1 inch to 7 miles, which show by means of shading the distribution of crops and livestock in Dorset. Non-agricultural land utilization is not dealt with, nor do such topics as agricultural technique and marketing fall within the scope of the book. The distributions given are interpreted briefly in terms mainly of physical conditions, for which purpose a map of "natural land types," based on geological outcrops and the availability of water supplies, has been prepared. A map showing "land-use units," which is drawn on the basis of the distributions given, sums up the study, and comparison is invited between this map, based on statistical data, and the "natural land types" map which has an independent origin. The correspondences between these two (Figs. 1 and 22) are striking, as we should expect, for the physical map inevitably indicates the agricultural potentialities. Mr. Tavener rightly reminds us however that personal, political, and economic factors, "working within the range of the more permanent natural factors," influence present land use, so that his "land-use units," in contrast to his "natural land types," have a somewhat temporary character. His "natural land types" are more familiarly known as "natural regions."

Less general discussion of land classification is given here than the subject demands and less than the sub-title promises. We can agree that the geographer, by training and technique, is well fitted to define the present uses of the land and to suggest improvements therein, although the contributions of agriculturalists in this field are noteworthy. It is less easy to agree that the objective of such work is "the most efficient land use," for the term "efficient" lacks scientific precision. Is it to be interpreted in economic terms, present-day or "long run"? Or does it relate to the potentialities of different types of land as attested by history or as deduced from physical circumstances? Whether the Chesil Bank should be used as a bird sanctuary or as a bombing ground for instance cannot be resolved in terms of efficiency. Moreover Mr. Tavener ventures no assessment as to how far the land is adequately utilized at present, and how far, from the geographical standpoint, this utilization might be improved. Nor is he concerned to show the uses to which the land of the county has been put in times past.

One methodological point may be noted. Mr. Tavener admits, though he does not discuss, the critical objections to the use of parish units in mapping official statistical data. These objections are real, for the parish boundaries commonly run at right angles to the geological outcrops: much of geographical significance is bound to be masked by mapping average densities or percentages for parishes as a whole. Except for highly generalized purposes therefore such distribution maps do not provide a firm and unobjectionable basis for the map of "land-use units," though we note that the boundaries shown on this map have been "checked and refined" in the light of local knowledge.

The author does not discuss the kindred work of the Land Utilization Survey, nor clarify his position in relation to this. As a review of land utilization in

Dorset, Mr. Tavener's work cannot claim the precision attainable by the methods of the Land Utilization Survey. By the methods of the latter, fields are surveyed individually, and as a result, within the limits set by the classification adopted and by the accuracy of the field work, actual geographical boundaries can be demarcated with an exactitude unobtainable from present official statistics, some of which might usefully have been added, as an appendix, to Mr. Tavener's useful monograph. W. G. E.

COMPANION INTO DORSET. By DOROTHY GARDINER. *London: Methuen & Co.*, 1937. 7½×5 *inches;* xii+288 *pages; illustrations and map.* 7*s* 6*d*

This is the charming book we should expect from the author of 'Companion into Kent,' distinguished by freshness both of matter and manner. There are many ways of envisaging our English counties, and their interests are practically inexhaustible. The motorist, the hiker, the settler in a district, the holiday-maker who seeks a month's quietude in some sequestered village, the resident, all ask for a somewhat different emphasis. Perhaps it is the last three who will most enjoy pages suited for leisured reflection rather than for hustling through. The writer has delved in records to pleasing purpose, chooses resolutely the less familiar character or episode, and the forgotten more than the favourite, and so greatly enriches the sum of local history. Places are subtly humanized by connection with family and personal history: the author has a special fancy for, and facility in mediaeval reminiscence. Literature is constantly made the background. Thus, she sees the Great Heath through the eyes of Thomas Hardy, and accompanies William Barnes while he takes his children for an outing among the scenes of his youth; at Racedown we fall in with the Wordsworths, and there are George III and Fanny Burney at Weymouth. But her eye for the external, scenery of hills or botanical treasures of riverside meadow, is equally alert. Since her subject-matter in itself always holds attention, there is no need for a plethora of interrogations. Dorset, comparatively little written about, still retains a liberal share of unspoilt beauty and interest. The reviewer, who has in three long excursions walked most of it with an eye mainly to scenery and antiquity, feels that he has gained a new insight from these pages, and where he follows on familiar ground the picture glows with colours more mature.

The plates are good. The map might be better. S. E. W.

FARMING ENGLAND. By A. G. STREET. *London: B. T. Batsford*, 1937. 8½×5½ *inches;* viii+120 *pages; illustrations.* 7*s* 6*d*

Mr. Street writes not only as a successful farmer but also as a pungent critic of all things and persons related to the land. On the one hand he reminds us of current trends in farming technique and agricultural production; on the other he condemns with equal relish both agricultural inefficiency and the short-comings of governmental policy. He invites us to share his sentimental attachment to the land of which we are all trustees, and emphasizes the difficulties under which farming is practised in such an urbanized and industrialized country as our own.

In this short and readable book, the product of numerous journeys, Mr. Street attempts to capture and express the individuality of farming in the different major regions of England. As a result we are given cameos of farming in twelve broadly differentiated areas, such as East Anglia, the South-West, and "London's Back-Garden," about which Mr. Street prognosticates grimly. The numerous photographs are seldom merely ornamental. Though slight in scale and provocative in style, this book provides, for the general reader especially, a useful bird's-eye view of land utilization and its problems in England. W. G. E.

THE SPIRIT OF PARIS. By PAUL COHEN-PORTHEIM. *London: B. T. Batsford*, 1937. 9×5½ *inches;* x+118 *pages; illustrations.* 7*s* 6*d*

This is an excellent translation of a book which was first published in German in 1930. The date is significant: Paul Cohen-Portheim evidently deeply believed in Paris as the centre of an European culture and there was little then to belie the quiet optimism in his evocation of its spirit. Only a wide knowledge of other capitals enabled him, in little more than a hundred pages, to portray the essentials of a city which satisfies the conservative and bourgeois soul of France, and yet acts as a world centre of culture and distraction. If Notre-Dame had remained its centre, Paris might have been as Vienna is to-day, huddled round St. Stephen's. Nor has Paris, like Berlin, but recently asserted its supremacy. Partly because of its position in Europe, and partly because it has been so long a capital and has known how to adapt itself to changing needs, it combines the attractions of its possible rivals. The author is sensible to the charms of each of its many facets: the boulevards, the mediaeval city, the aristocratic and provincial quarters, and the Quartier Latin. His epitomes of its architecture, drama, and painting are classic in their conciseness and the wit that is not without a touch of malice. The same wit has gone to the choosing of the numerous plates which are beautifully reproduced. It is a pity that more care could not have been taken in the choice of type. J. P. H. M.

TOWN AND COUNTRY IN SOUTHERN FRANCE. By FRANCES STRANG. *London: Macmillan & Co.*, 1937. 9×6 *inches;* xvi+158 *pages; illustrations (by Ian Strang) and sketch-map.* 12*s* 6*d*

The authors present a set of beautiful landscape drawings accompanied by travel notes which have an amateurish architectural bias. "There are great monuments everywhere" in southern France, and truly, the natural features as well as the buildings group themselves nobly in the work of the illustrator. The Midi, with its limpid atmosphere and good visibility, is peculiarly fitted as a subject for the pencil of Mr. Ian Strang, and justifies his almost mediaeval convention of elaborate detail. The middle distance is brought forward, as by a telescopic camera lense, with a skill of selection that is as delightful to the geographer's eye as it must be to that of the artist. A lovely example is the drawing of the valley of the Dordogne showing the broad flood plain with a corner of cultivated terrace land in the foreground, a sharp loop of the river enclosing an alluvial core under strip-cultivation, and beyond, still vividly clear, the banded limestone escarpments of the gorges exposed in the incised meanders cutting into the wooded plateau which stretches to the horizon.

The authors by no means confine themselves to "monuments," and among the many attractions of this volume are the intimate studies of domestic architecture and the tags of local gossip and information afforded to travellers who "mixed freely with and got to know all manner of people." H. O.

RECHERCHES GÉOLOGIQUES DANS LES PYRÉNÉES BASQUES d'Espagne. By PIERRE LAMARE. *Paris: Société Géologique de France (Mémoire No. 27, N.S. Tome XII)*, 1936. 13×10 *inches;* 462 *pages; maps and profiles*

The region dealt with comprises the area bounded on the north by the coast from San Sebastian to Fuenterrabía and the Franco-Spanish frontier as far as Mount Idusquimendi, on the east by the continuation of the frontier as far south as Mount Isterbegui and thence to Zubiri, on the south, from Zubiri to the valley of the river Araquil by the edge of the Tertiary basin of Pampeluna, and finally on the west by a line running from San Sebastian to Lasarte, the river Oria and Mount Txindoky. For many reasons this area has been relatively

neglected, but Dr. Lamare has spent fifteen years in studying it in detail, and his results are embodied in the present volume.

In many published works on tectonics there is unfortunately no unanimity in the use of the necessary terminology, so that a well-known term employed by one author is not always used in the same sense by another. Dr. Lamare is at pains however to define early many of his tectonic and stratigraphic terms, so that the reader may not be under any misapprehension.

The author recognizes three main massifs from north to south, those of Rhune-Haya, Cinco Villas, and Quinto Real. It is important to note that structurally these are intimately linked with the structures of the French Basque Pyrenees and not with those of the Sierras of Aragon. In addition, the author recognizes other morphological units, such as the Coastal Region, the "Nappe des Marbres," the Intermediate Depression (separating the massif of Cinco Villas on the north from the mountains corresponding to the Nappe des Marbres and the Massif of the Quinto Real), the Secondary Envelope of the Massif of the Quinto Real and its westerly prolongation, and the "Écaille de Aralar" (the isolated, triangular mountain group of the Sierra de Aralar). Each of these is considered in turn, and a useful summary of the geological succession included in each section before the details of the structural features are given. Finally, before the tectonic results are summed up, an account of the geological history of the region is rendered, palaeogeographical considerations are taken into account, and some brief mention made of the occurrences of the igneous rocks.

Tectonically, the area suffered its major stresses and dislocations in the Hercynian and the Pyrenean earth-movements, although other periods of folding and faulting can also be detected, such as the pre-Cenomanian folding which affected the Hercynian block to the north of the Elizondo-Leiza depression. In the solution of the major tectonics the important rôles played by the various formations is emphasized. Thus, under stresses the Keuper may "flow," or act as a lubricant to moving earth masses, or form a chaotic agglomeration with other horizons ("structure en glaçons"). The Triassic and Cretaceous grits, and the Jurassic and Cretaceous limestones however behaved as rigid masses in the Pyrenean earth-movements, and gave rise to a number of great dislocations of different type. The results thus show an analogy with those obtained in other parts of the Pyrenees, and not with those of the Alps.

The volume is plentifully illustrated with explanatory sections, and the maps are convincing. The author deserves well for the arduous task he has completed, and for the way in which he has presented his results. H. D. T.

PORTUGAL. II. Teil: Die portugiesischen Landschaften. By HERMANN LAUTENSACH. (Petermanns Mitt., Ergänzungsheft Nr. 230.) *Gotha: Justus Perthes*, 1937. 11×7½ *inches;* viii+166 *pages; illustrations and maps. M.*20

This follows a previous volume, 'Portugal: Das Land als Ganzes,' written by the author six years ago. It adds to that broader study a detailed statement of Portugal's regional character, thus completing the geographical survey. Consequently generalities are at a minimum in this volume; the bulk of it consists of a group of sketches of each region, with the influence of Passarge very strong. Not much space is given to discussing alternative regional divisions. The author rightly inclines to the view that regional studies have value less in regional delimitation and more in their regional presentation. They are successful when they give the completest possible picture of whatever regions may be chosen.

In his thesis Herman Lautensach uses the division made classic by Amorim Girão, based on *nomes de pays* current among country folk themselves. His

word pictures are extremely effective and illuminating. He conveys the true "feeling" of the landscape because he writes as much from what he has seen as from what he has read. While his bibliography is probably the most complete on the subject at the present time, Lautensach spares us the over-annotation with which academic geographers show their scepticism of any fact which is not stated second-hand. Other aids to regional exposition however are inadequately used. Maps and photographs in detail are deplorably few and they are gathered at the end of the book instead of where they might supplement the letterpress. Two photos and no map cannot adequately illustrate any region.

His regions differ from those of Girâo on two points. He distinguishes the Algarve Mountains from the Algarve Coast, an important demarcation since the coast differs as much from the heights behind as does the comparable Spanish Malaga coast from its backing, the Alpujarras. Then again, Lautensach accentuates the economic character of the Alto Douro. He bases his unit there on the results of research by the Casa do Douro into the question of which parts of the Douro Gorge produce wine considered to be "Port" in quality: a fine example of one product creating a geographical region.

The book normally assumes that the rhythmical character of any unit is stated when its climatic rhythm is detailed. This is far from true. In regional description we require to know the detailed impression which climatic rhythm makes on occupations of men and on habits of animals. In this study the cycles of movement and activity are discussed as a whole in one chapter which, although very good, clearly distinguishing the component cycles, covers the whole country at once and gives no idea of the individual regional vibrations. We miss, too, a discussion of the interaction between one region and another and of regional perspective, that is, the relation of present tendencies to those of the immediate past.

The human aspect of Portuguese geography is here rather lightly passed over. Rodney Gallop's work remains unique in its review of peasant customs in the various regions. Standards of life and manner of living are hardly noted. Geographers are apt to forget this side of their observations; yet by expressing social facts judicially weighed and balanced with other circumstances, they have at hand the power to remove social facts from their controversial background. Though Lautensach refers only lightly to such points, he leaves the suggestion that rural problems and agrarian discordances make Portugal an unstable point should social stresses from other parts of Europe act upon it. He has continued to justify his reputation as one of the standard foreign authorities on Portuguese geography from the modern point of view. E. H. G. D.

SONS OF THE EAGLE: wanderings in Albania. By RONALD MATTHEWS. *London: Methuen & Co.*, 1937. 8×5½ *inches;* xii+302 *pages; illustrations and sketch-map.* 12*s* 6*d*

This is the third book on Albania which has passed through the reviewer's hands within as many months. It lacks the generous humanity of the first of its predecessors, and the remarkable sensitiveness to natural beauty of the second, but in several commendable respects it is superior to both. The only discernible straining after effect is in the style, which is perhaps too coldly perfect. There is also not a single sentence that aims at making the reader say what a hero the author must be to venture into such a wild country. Personalities are refreshingly absent, with the happy result that nobody in Albania will suffer for having his name mentioned. This continence is the more striking in that it is the daily life of Albania—in peasant's home, government office, and public coffee-house—that is the subject of the book.

The author begins with his landing at Durazzo. At Tirana, well described as a capital and nothing more, with a new-toy atmosphere surrounding all the appurtenances of government, he relates the dreams that are doomed by national poverty and perhaps by the national character to remain dreams. A rapid résumé of Albanian history, with an imaginary English parallel to put it in perspective, leads to a description of the mediaeval bazaar of Kruya, home of Skanderbeg, the national hero who was long the bulwark of Europe against the Turk. And so to the northern mountains—first to Scutari, no longer an important outpost of the important Turkish Empire, but a decaying market-town stranded in a corner of little Albania; then to the Highlands with their primitive laws and beliefs and their crying need for roads so that the peasant may get his produce to proper markets and escape the starvation that is too often his present lot. After Mirdita, where the author confesses himself ingenuous enough to have tried to "draw" Captain John, comes Lura, and then Mat, birthplace of King Zog, an enigmatic personality given, as the author acutely detected at his own audience, to politely deluding his visitors. The book ends with a few chapters on South Albania—on Valona where the standard of Albanian independence was raised in 1912 and kept flying in 1920, on Korcha with its American veneer, on Elbasan distinguished as the seat of Shefqet Bey Verlaci, the only Albanian who is rich by English standards, on picturesque Berat and massive Tomor, and on Gjinokastër. From first to last both the author and the interpreters placed at his disposal by the Albanian Government so that he might write up the country for the enticement of tourists, did their part well, the author because he preserved his independence of judgment and pen, and the interpreters because they guarded his book so efficiently from the mistakes inherent in any work of man that his worst howler is ascribing to Scutari on p. 100 a photograph of the bazaar at Elbasan. His assertion that Tomor is a "mountain of Zeus" is, of course, fantastic. But when one has read to the end, one can but gasp. Did the author never see a sunset or a cloud, a shapely mountain or a colourful plain during his wanderings? On all these matters, which are the glory of Albania, he is dumb. M. M. H.

ASIA

NEWSGIRL IN PALESTINE. By BARBARA BOARD. *London: Michael Joseph,* 1937. 9×5½ *inches; 292 pages; illustrations. 12s 6d*

The chief merit of this amiable volume is the disarming simplicity with which the author describes her experiences. Miss Board has made a rapid tour of Palestine and parts of Transjordan, discussed their mode of life with a number of residents of those two countries, for the most part women, and faithfully recorded what she was told. At a time when feeling runs so high Miss Board may be congratulated on having wholly avoided the faintest trace of political or racial bias in her account. This is achieved by a complete elimination of anything remotely connected with the public affairs of Palestine: Miss Board concentrates her attention entirely on the private lives and habits of the less familiar types of Jews and Arabs, supplemented by occasional accounts of conversations with public officials, English and Jewish. She spent some days among the Badawin, obtained admission to the harem, and was granted an interview with the principal wife of the Emir of Transjordan; chatted a little to the Orthodox nuns in Jerusalem; and listened to a lecture on the proper method of building a model of the Temple delivered by the daughter of the original modeller: this last appears to be reproduced in full, with relevant biblical quotations, and occupies an entire chapter. There are a number of

minor inaccuracies (*e.g.* "Igumeni" is not a proper name but "Igumenia" is the Russian for "Mother Superior"; the Passover and Feast of the Unleavened Bread are not two festivals but one. The edict against bigamy among Western Jews was issued not in the seventeenth but in the tenth century, etc.). This is a naïvely composed, agreeable, uncritical, slightly childlike book, written with great directness and genuineness, and a charming sympathy for every one and everything. The title is however deceptive, since no one in search of news of the recent affairs in Palestine will find any here. I. B.

FORBIDDEN ROAD—KABUL TO SAMARKAND. By ROSITA FORBES. *London: Cassell and Co.*, 1937. 9 × 5½ *inches;* xii + 290 *pages; illustrations and route-map.* 15*s*

It has lately become increasingly the habit among authors of travel books to refer to their journeys as passing through forbidden territory; but, while many frontier districts are now closed even to the most innocent travellers, many have found that the passage may often be made by the comparatively simple expedient of making the attempt. This formula is not without exception, but Miss Forbes' account is a proof in at least two instances, Afghanistan and Russian Turkistan.

Miss Forbes' journey from India through Afghanistan to Russian Turkistan and Moscow covered relatively familiar ground, and therefore makes little contribution to geographical knowledge. Nevertheless the conditions under which people live afford material for study, and Miss Forbes describes with her usual energy how these conditions affected her. Unfortunately both in Afghanistan and Russian Turkistan she had to rely on finding someone who could speak a language she knew; and therefore her accounts of the sentiments of the indigenous population towards the conditions under which they live—a point of equal interest with the conditions themselves—are necessarily second-hand. Those who can afford the leisure to travel and retail their experiences would deserve better of the reading public if they prepared themselves for their journeys by obtaining something more than a smattering of the languages common in the countries in which they plan to travel.

From Peshawar to the Russo-Afghan border Miss Forbes travelled by lorry on the new roads developed by the shrewd and not too westernizing rulers of Afghanistan. Her account and others recently published show that the Afghan government provides in many ways an object lesson to other Asiatic rulers. The British Legation at Kabul provided Miss Forbes with an escort in the person of Captain Galloway to accompany her across the Hindu Kush. The Afghans however are so courteous and hospitable a race that a journey by a European offers little if any greater peril than the day-to-day hazards to be met with in much more civilized countries.

The crossing of the Oxus presented a more difficult proposition since communication across this frontier is restricted. Both sides claim that the other is all but starving. From England it is possible to observe that neither view is correct. Miss Forbes' account of Russian Turkistan shows that the effects of the famine in 1932–33 are mainly overcome, though whether this is due to better seasonal weather or improved and more popular application of Soviet theory is not apparent.

Naturally Miss Forbes suffered the usual difficulties of a traveller ignorant of the language in attempting to observe a time schedule. The reader may consider that the account of her difficulties in these respects occupies too much of the book since there is so great a variety of information that the student of Central Asian affairs would wish as an alternative. This remark has the greater

application since the beauties of Samarkand and Bokhara, to which Miss Forbes also devotes a good deal of attention, are already described in a number of authoritative works. Her writing however is always vigorous and her style is vivid. Those who have enjoyed her previous books should certainly read this one. B. E. M. G.

RESA TILL LOP. By NILS HÖRNER. *Stockholm: P. A. Norstedt & Söner*, 1936. 10×7 *inches;* 328 *pages; illustrations and map*

Dr. Hörner, who is now a Lecturer at the University of Uppsala, joined Sven Hedin's Central Asiatic Expedition in 1929 and was continuously engaged in geological research in the field until 1933. This general account of his observations and experiences is divided into three parts. The first describes work in the Gobi and among the Nan Shan, or "Southern Mountains," where an examination of the rocks and glaciers led the author to the unexpected conclusion that ice had never covered a much larger area than at present.

The second part is devoted to the daring and successful journey which gives the book its title. In the autumn of 1930 Dr. Hörner was preparing to travel southwards through unmapped country to Koko Nor, when a bearer brought an urgent message from "the chief," instructing him to find and survey the new Lop Nor. The river feeding the lake was reported in 1928 to have returned to its old bed, exactly as Hedin had predicted a generation before, thus raising many interesting problems, but Hedin and various members of the expedition, as well as other travellers, had hitherto failed to obtain permission to visit the region from the Governor of semi-autonomous Sinkiang. Now the central authorities in Nanking had agreed to a plan for reaching the lake directly from Kansu, to the east, avoiding all contact with the inhabitants of the province in which it lay. As the journey could only be made in winter, Dr. Hörner and his companion Mr. Parker Chen, the Chinese astronomer and geodesist, preferred not to wait for the extra provisions and equipment which were being sent from headquarters in Peking; they collected what they could locally and set out at once. On New Year's Eve, 1930, after encountering many difficulties, they finally reached their goal, which they were the first to see in its new form. In spite of weary and footsore camels, scarcity of water and uncertainty about future supplies, the explorers and Banche, their loyal Mongol, overcame the caravan men's reluctance and proceeded to follow and map the shore of the lake. Hard rocks of dried salt often made progress slow and painful, but two months later they had worked their way round to their starting point again, having made important observations.

The third part of the book, "War and peace," is concerned with shorter journeys in the bandit-ridden province of Kansu and the peaceful area of Etsin Gol to the north, where Dr. Hörner spent fifteen months in Torgut Mongol territory. The desiccated lake of which he first found traces in 1930 had been identified by Dr. Folke Bergman, the archaeologist, as the Chü-yen-hai or Chü-yen-tzu of early records, and further study revealed a striking parallelism between the "alternating lakes" of the Lop Nor and Etsin Gol regions; the changes in the water system seem to have caused rich settlements to be deserted in each case.

The geological results of Dr. Hörner's investigations have been summarized in "Geomorphologische und Quartärgeologische Studien," *Petermanns Geographischen Mitteilungen*, 1935, Heft 9/10 (pp. 286–7). 'Resa till Lop,' while exciting the general reader's interest in the structure of the country, also includes other types of material, such as a suggestion that anthropologists should study the so-called "Western Tibetans" of Nan Shan, besides attractive accounts

of camp and caravan life and the author's occasionally dangerous adventures. He pays warm tribute to the skilful leadership at the base which made the work of the different groups of scientists possible, to the sterling qualities of his collaborator Mr. Chen, and to the achievements of many other members of the expedition, although very modest about his own. The 112 photographs, all taken by Dr. Hörner, are extremely good, and those more strictly geological in subject-matter are often particularly beautiful. The absence of an index is regrettable, and the narrative would have been clarified by a few more dates, but there is a clear, detailed, and convenient map. E. J. L.

THE LURE OF JAPAN. By SHUNKICHI AKIMOTO. *Tokyo: The Hokuseido Press (and Board of Tourist Industry, Japanese Government Railways) [London Agents: Edw. G. Allen & Son]*, 1934. $7\frac{1}{2} \times 5$ *inches;* xvi+372 *pages; illustrations and sketch-maps.* 6*s*

JAPAN'S ADVANCE. By JAMES A. B. SCHERER. *Tokyo: The Hokuseido Press (London Agents: Edw. G. Allen & Son)*, 1934. 9×6 *inches;* xviii+348 *pages; illustrations.* 15*s*

These two books are largely concerned with conditions in modern Japan, but they are more noteworthy for their contrasts than for their resemblances. It is obvious that they have been written with different objectives, and the authors—one a Japanese, the other an American—naturally diverge in their modes of thought and expression. Yet they share a common admiration for the efficiency and energy of present-day Japan, and an ability to impress this conception on the minds of their readers.

Mr. Shunkichi Akimoto's book is published by the Board of Tourist Industry for the purpose of interesting the foreigner in the country and inducing him to visit it. That it will achieve this object is by no means certain. The author has tried to combine a guide-book with a chatty discourse on history and religion, relieved with incidents illustrating the culture and habits of the people. The scheme, to be entirely successful, would require the collaboration of a Murray and a Lafcadio Hearn. The guide-book part is too sketchy for practical use. The geographical sections do not attempt very much but are interesting and free from inaccuracy. It is doubtful whether the average Englishman will be able to read with profit the numerous paragraphs devoted to history and culture. The author's discourses on these matters are anecdotal and without historical continuity or cohesion. They do not present a definite picture for the mind to grasp. Nevertheless those who are content to acquire some superficial knowledge in an easy way may enjoy a perusal of the book. It calls for little effort or concentration if the reader can accustom himself to Mr. Akimoto's style, which is rambling and verbose.

Mr. Scherer, on the contrary, is an American whose pleasant style is free from all adornment. He sets out to tell the truth about Japan as he sees it. His book breathes an honesty of purpose and a sense of logic and proportion which carry conviction. The author knows his subject, having lived many years in the country, where he was once a teacher in a government school. Since those days he has mixed freely with all classes of the population, and has had intercourse with acknowledged leaders in such diverse fields as politics, industry, finance, and literature. Further, he has made full use of his ability to observe, and has been careful to analyse and sift his material. He reveals much that is new, and much of value on a variety of subjects extending from the historical background of the nation to the latest improvements in machine tools; from developments in the spinning and canning industries to Japan's place in the world, and her present economic and political position in relation to England, America, Russia, and Manchukuo.

Some of these topics are contentious, but they are presented in a manner which stimulates interest and encourages careful thinking. The author deals with law, with wages, labour, education, and leisure. He is at once sympathetic and critical. He strives to be impartial, and is probably unaware of the defensive strain underlying many of his arguments.

In an acute survey of the position of women, he tends to overrate the advance that has occurred during recent years. Undoubtedly their emancipation has been hastened by the changes that have caused the transfer to the factories of multitudes of young women, who had formerly performed domestic duties or helped their fathers and brothers in the fields. The economic independence attained by this large class has helped to further the social and legal freedom of women generally; but, in spite of changes, their standing in Japan is still inferior to that of men.

The author advances the theory that the rapid progress of Japan is primarily due to the national system of education. This system has quickly succeeded in guiding and training a population gifted with fertile brains and deft hands. It has been assisted by the frugal and persistent nature of the people, inherited from generations of forbears who fought and strove for existence in a land where little of the soil will support life without intensive cultivation, and where the fruits of years of toil may be destroyed by natural cataclysms in a few moments.

The belief that the Japanese are good copyists, but unable to originate, dies hard. They have been experts at adaptation ever since they adopted the civilization and culture of China, and exercised much skill in fashioning them to suit their own ends. Mr. Scherer is at pains to refute this idea of want of originality. He shows how Dr. Mishima invented a steel alloy which is not only much cheaper to produce, but is superior in strength and usefulness to any of the magnet steels hitherto existing. Again, a remarkable automatic loom for the cotton industry was invented by Toyoda, a Japanese, which functions with one woman handling up to sixty units.

Mr. Scherer's contention that he writes for the man in the street and not for the serious student, while indicating a becoming modesty, scarcely does justice to his work. It is of interest to the average man, but it equally deserves the attention of the serious student because of its reasoned argument and the wealth of information it places at his disposal. The student moreover will be grateful to the compiler for the inclusion of the admirable coloured graphs, which enable statistics to be memorized with ease. The book, in spite of its sound commonsense and other engaging qualities, is not sponsored by the Board of Tourist Industry, and contains no evidence of any intentional attempt at propaganda. It is at least conceivable however that it will attain an object of far greater importance than the amusement of a few tourists. It may spread abroad an appreciation of Japan's problems and difficulties, and thereby contribute to an understanding which is so urgently needed. G. M.

AFRICA

DIE BAJA: ein Negerstamm im mittleren Sudan. By GÜNTER TESSMANN. Ergebnisse der 1913 vom Reichs-Kolonialamt ausgesandten völkerkundlichen Forschungsreise nach Kamerun. Bd. 2 (Schlussband). Expedition zu den Baja 1913–14. Teil 2. Geistige Kultur. *Stuttgart: Strecker und Schröder*. 1937. $10\frac{1}{2} \times 7$ *inches;* vi + 182 *pages; illustrations. M.*15

This volume completes an earlier one describing the material and psychological culture of this people of Eastern Cameroons visited by the author in 1913–14.

It is illustrated by numerous excellent photographs. In the first part the author deals with the religious beliefs. The Bayas believe in a supreme being *Gbaso*, "the Great-Soul," who created things and had children; he was fond of one son, Uanto, but sent the others away. Uanto reproached him for this and brought his brothers back. He also managed to find out how Gbaso made fire and got water, and then Gbaso went up to the sky and left men to Uanto. The author does not point out the traces of Christian teaching which this tale bears.

Souls are not identified with shadows; they can leave the body in sleep and when illness brings on unconsciousness. In this latter case they go to join the predeceased, but are sent back by their ancestors who desire descendants. Death is followed by judgment. The souls guilty of murder, adultery, or theft are sent to a Hades; the others become the children of Gbaso if they belonged to chiefs or nobles. The souls of underlings go to a bushland, according to most Bayas, but those of Bogota are more democratic and do not separate souls according to their social rank. When a young person dies it is said that Gbaso loved him and desired his company.

Sorcerers are believed to be possessed by spirits and are not considered responsible for their wrongdoings. The author has made a minute study of the plants used by good and bad sorcerers to cure or to injure.

The ceremonies connected with the initiation of the *labi* members, a semi-religious and social organization, were witnessed by the author, who describes them minutely and likewise those of the *gadsa*. The word *nganga* used to designate the spirit received during these ceremonies reminds one of the Bantu *nganga* "doctor," and of the Fulah *gana* "wise word" or "word with a secret meaning."

Tombs are dug before the houses in a north–south direction and the bodies are laid on mats supported by short posts, the legs drawn up as in sleep; men's heads are laid towards the north, women's towards the south. Women known for frequent conjugal infidelity are buried in the bush. The first to die of twins is put into an earthenware pot, which is placed on a three-forked pole on the road leading out of the village, where it remains till the second dies.

Weapons are varied and include spears, bows and arrows, maces, swords, daggers, knives (one throwing knife), and a hook to catch the foot of an opponent. Five kinds of shields are described.

The Bayas are conscious of what they have acquired from the Fulahs, but the author thinks they have borrowed much from the Bandas, their northern and southern neighbours, and from the Kares, and a little from the Pangwes.

The questions of birth, marriage, legislation, weather, and the conceptions of the heavenly spheres are fully treated.

Certain general theories might be questioned, but they are not an essential feature and do not diminish the value of this volume. L. H.

CONTRIBUTION À L'ÉTUDE DE LA VÉGÉTATION FORESTIÈRE de la Haute-Côte d'Ivoire. By L. BÉGUÉ. (Publns. Com. Études Hist. et Scient. Afrique Occidentale Française. Sér. B. No. 4.) *Paris: Larose*, 1937. 10 × 6½ *inches; 126 pages; illustrations and map*

This book deals with the savannah regions of the Ivory Coast, which have, under human influences in the course of centuries, replaced the primitive forest still occupying the southern part of that colony. The area dealt with extends from the portions drained by the rivers discharging into the sea northward to a part of the Niger Basin. After outlining the ecological features, soil, relief, and the agricultural habits of the inhabitants, a close study of the arborescent vegetation of the different regions between the dense forest and the northern

boundary occupies the greater part of the book. The intimate detail in which the tree associations are recorded for a very large number of localities of diverse aspect, thicket, wooded glade, islet of isolated forest, open stretch or marsh, river fringe or laterite outcrop, indicates the patience with which the author has used his notebook on the spot. The reiteration would be wearisome without the résumé after each short section referring by numbers (not infrequently misprinted) to the photographs, sixty-two in number, placed after the main text, giving an adequate view of the great variety of formations encountered. Amidst an apparent complexity some real continuity exists of certain types of associations, from which one may infer the nature of the original covering, the changes which have brought about the present conditions, and their causes.

There is a broad distinction between closed and open formations, with a continuity in gradation from semi-deciduous to xerophilous from south to north, and a corresponding gradation of climate, which is drier more or less according to latitude over the same area. Abundant vestiges of closed vegetation are evidence that this type was probably once continuous. Islets of forest separated from a gallery, trees, isolated or grouped, which are species proper to the forest, even the village palaver tree or the few left at a railway station, may serve as "indicators" in this respect. The vegetation characteristic of termite hills, often attributed to an enriched soil, is made to serve the same argument, the author's conception being that this association is composed of species representing a persisting closed formation. Also, on the assumption that the formation of laterite demands moist conditions and a prolonged period of time, the climate must in the remote past have been humid even in the north where now the rainfall is scanty. The author's theory is that the climatic formation is a closed one, and he asks whether a reverse evolution of the open savannah to the closed type is possible. His answer is yes, very slowly, but only on condition that fire could be completely suppressed. The abrupt transition from closed to open is only due to the action of fire, which is powerful and rapid in contrast to the very slow natural recovery which is believed to be possible. A portion of forest reserve near Bouaké is cited as having been effectively protected from fire for several years and already shows an advance of arborescent growth beyond its margins, this in turn creating a micro-climate favourable to farther extension.

A map shows the limits of the sections described, and gives also isohyets indicating the wide range of humidity. A useful appendix furnishes a list of the principal forest species with vernacular names in three dialects. J. M. D.

LE CAMEROUN. By HENRI LABOURET. (Centre d'études de politique étrangère. Travaux des groupes d'études. Publication No. 6.) *Paris: Paul Hartmann* (1937). $8\frac{1}{2} \times 6\frac{1}{2}$ *inches;* viii + 260 *pages; sketch-maps and diagrams.* 20*fr.*

When M. Labouret went out to compare the political and economic situation of the French Mandated Territory of Cameroons with that of the pre-war German Protectorate he found himself in a difficult position. Firstly the area comprised was not the same, for about a sixth of the country had been mandated to Great Britain, and about a third of the remainder had been annexed to French Equatorial Africa and was not under mandate at all. He further found that all the German records were at Buea, the former capital, now in the British area, and none had been published. He could thus give only an account of the country as he found it. His very full description, supported by statistics, contains paragraphs on geography, administration, the natives, the judicial system, agriculture, health, education, commerce, railways and roads.

The area of the territory is 429,000 square kilometres. Mountainous on the west, the central part is a tableland over 3000 feet in height. Apart from a little rain forest near the coast, savannah-type woodland prevails. Agriculture predominates, and out of a total export of 126,000 tons in 1935, the principal tonnage is represented by palm kernels and cocoa. The native population may reach two millions. The foreign population, steadily increasing and mainly French, was 2324 in 1935.

The aim of the mandatory power has been to make the country as French as possible. The acquisition by the natives of the French language is the basis of the educational system. In contrast with this it may be noted that the Germans found English the common language, at least in the regions nearer the coast, when they declared their protectorate, just at the moment when at the request of the natives the British Government was about to do so; and English remained the common language of intercourse during the German occupation.

"Whenever two unequal civilizations find themselves in contact, the inferior imitates the superior in order to raise itself to level of the latter," says M. Labouret. This it has been French policy everywhere to assist. Hence segregation of the natives under a system of Indirect Rule has not been adopted. The French system is best seen in the position assigned to the native chiefs. The Chief's duty is "to maintain public order and especially to serve as intermediary between the European administration and the inhabitants of his area." He transmits orders, and makes all necessary arrangements for the collection of the poll tax. He further has to carry out any orders given him as to sanitation, economic crops, etc. For the manifold duties he has to perform M. Labouret considers most of the chiefs underpaid, often receiving no more than a percentage of the tax money collected by them. Only very restricted judicial powers are left to them. They are little more than conciliators. Justice is administered by a French official sitting with two native assessors.

The French judicial organization, like that of the Germans before them, is founded on respect for local customs provided they be not contrary to the moral principles of western civilization. It is recognized that local customs may be very local, and that they may vary according to the social position of the individual in the tribe, custom as applied to nobles not being the same as that for ordinary freemen or for slaves. Since it is the essence of custom that it is always changing, codification though often advocated is yet to be carried out, and its advantages (except as an ethnological record) in a society desiring and urged to advance are subject to doubt.

Comprehensive as M. Labouret's survey is, there are a few points on which further information would be interesting. Labour for private enterprise is carefully and well regulated. No reference is however made to the supply of labour for Government purposes such as building and maintenance of bush stations, construction and maintenance of roads, and transport beyond the limits of the railways or motor services. Mention of the military forces could not be expected. The police however are omitted also.

It is creditable to find that the territory has been developed mainly from its own resources. The only loans raised have been two, amounting together to 57,000,000 francs.

The value and interest of the record under review are great. It is clear that the French appreciate their mandate and are keenly desirous of increasing the prosperity of the country. F. W. H. M.

AUSTRALASIA AND PACIFIC

CANOES OF OCEANIA. By A. C. HADDON and JAMES HORNELL. Volume I. The canoes of Polynesia, Fiji and Micronesia. By JAMES HORNELL. (Bernice P. Bishop Museum. Special publication 27.) *Honolulu, Hawaii*, 1936. 11 × 7 *inches;* x + 454 *pages; illustrations*

The first volume of this long-awaited publication more than fulfils expectation. If, in the last of the two volumes yet to come, an Index is included, its compilation will tax the skill and vigilance of a corps of indexers. The technology of canoes forms a complex of descriptive morphology such as could be attacked by no investigators so well qualified to succeed as the two authors who have produced this monograph. Each of them has been prepared by a long course of discipline in the literature, in the Islands, and elsewhere, whilst their earlier contributions to our knowledge of the canoes of Oceania have marked them out for this final task of analysis and synthesis.

On the efficiency and thoroughness of Mr. Hornell's treatment of the canoes that fall within the scope of the present volume there is no need to dwell. He steers us through the bewildering maze of structural detail with a skill born of long practice. In the Introduction he speaks of the amount of labour that was needed for the reconstruction of the now extinct canoe types seen by the early European voyagers. To the consulting and evaluation of specimens and models in museums have been added observations and sketches made by himself in the Pacific, and much devoted industry has gone to the production of the illuminating descriptions, drawings, and photographs, that give distinction to this work.

Space is not available to track the author's technological voyaging from Hawaii to the Marquesas, through the Tuamotus to Mangareva, Easter Island, and the Society Islands; thence to the Austral Group, the Cook Islands, New Zealand, and the Chatham Islands, with many intervening stoppages to describe the water-craft of single islands. By way of Samoa, Tonga, and the Ellice Islands he reaches Fiji, which in virtue of its Polynesian and Micronesian contacts and borrowings has been included in the present volume, instead of in that which deals with Melanesia. The Gilberts, the Marshall Islands, the Carolines, the Marianas, and the Palau Islands, make up the Micronesian section, though, as in the case of Polynesia, such summary grouping does not do justice to a treatment which explores many sub-groups and single islands throughout the area.

Whilst the technology of canoes forms the body of the volume, there is interpolated much that is of importance in relation to wider issues. Progress and degeneration in structure, origins by local development or by diffusion, results of colonization and contacts, disappearance and hybridizing of types, movements of peoples to and fro over the Pacific, indications of Melanesian blood in Polynesian islands, and many other subjects, receive discriminating attention. Justice is done to the nautical skill and enterprise of the Polynesians and Micronesians, and it is pointed out that at the time of the voyages of the early European explorers "the golden age of Polynesia was already a thing of the distant past." In the section on "Cultural diffusion in Polynesia and Fiji" (pp. 337–344), there is much that is of importance to students of Pacific migrations, and it may be noted that the author finds good evidence for the attractive view that the Proto-Polynesians having reached Hawaii by way of the Carolines and the Marshall Islands, at a later period sent offshoots southwards and westwards to colonize the Tuamotus, the Society Islands, and Samoa. Under this theory the approach to Melanesia was from the east and not the west.

That the style of production of the volume is worthy of its content is due to

the Bernice P. Bishop Museum; but our thanks must be tinged with regret that two distinguished British ethnologists have had to seek publication abroad for a monograph that deals so largely with British possessions. H. S. H.

POLAR REGIONS

GRENLANDIA. By ALEKSANDER KOSIBA. *Lwów-Wrszawa: Książnica Atlas*, 1937. 9½×6½ *inches;* viii+480 *pages; illustrations and maps*

The part played by Poland in exploration, especially arctic exploration, has so far been a minor one, confined to the participation of some of her scientists in expeditions organized by other nations. The results of the researches carried out by these scientists have, for the most part, not been published in the mother tongue, and Polish literature dealing with arctic regions is, in general, very sparse. The author states that the lack of "any kind of documentary material, even of a general character," concerning Greenland prompted him to endeavour to supply the deficiency, at least in part, by compiling this book. Dr. Kosiba was a member of the Greenland expedition organized by the Danish Geodetic Institute in 1934. The data resulting from observations in the course of that expedition, together with a careful study of relevant literature, furnished the material for the present volume. The excellent bibliography comprises no fewer than 285 works. The book, which is more in the nature of a general study than an account of the Danish expedition, covers a very wide field. It gives, in outline, the history of voyages to Greenland from the time of the Vikings down to the present day, briefly recording the achievements of the principal scientific expeditions organized in the course of the nineteenth and twentieth centuries. A fairly long chapter is devoted to a study of the region of the Inland Ice, and climatic conditions are also discussed at some length. The geological features of Greenland, its flora, and its fauna, have each been accorded their chapter. The history of whaling is given in brief. The book concludes with an interesting study on the Eskimo extending over 100 pages.

Discussing Greenland's climate, the author reminds us that our present knowledge of it is based on "very scanty and, in many cases, unreliable data." He points out that systematic observations ranging over a long period are needed in order to obtain tolerably reliable data regarding this most complicated climate. Up to the present however few expeditions have been able to carry out an investigation extending over a reasonable length of time. For instance, the Wegener Expedition of 1930–31 is the only one whose meteorological researches in the zone of Inland Ice cover a complete year. The author regards as inadequate the permanent meteorological stations which Denmark has established along the coast: "The majority are, of necessity, entrusted to laymen: to Danes who are in the region as government officials, hunters, etc., or even to Eskimo." He adds that some of these stations appear to have been set up by "unprofessional people," and that, in certain instances, instruments have been placed in position in a manner "which does not fulfil fundamental requirements of science."

The chapter on the Eskimo gives an insight into their material culture, portraying their hardy life as hunters and fishermen. It also tells us a little about their language which, the author suggests, can have undergone but slight modifications since the Stone Age, and about their primitive notions of arithmetic, their calendar, and their methods of reckoning the time.

The book is primarily intended for experts, but even the layman will find much interesting reading in the historical and ethnographical sections, and the numerous excellent photographs help to render it attractive. F. M. M.

PHYSICAL AND BIOLOGICAL GEOGRAPHY

THE FIRST HUNDRED YEARS OF THE GEOLOGICAL SURVEY

of Great Britain. By SIR JOHN SMITH FLETT. *London: His Majesty's Stationery Office*, 1937. $9\frac{1}{2} \times 6$ *inches; 280 pages; illustrations. 7s 6d*

The Geological Survey, as the late Dr. Bernard Smith reminds us in his Preface to this history, was the first official institution of its kind to be formed in any country. At the time geological science was in a state of flux and the inauguration of an official Department dealing with this subject stands as a landmark between the decline of the Wernerian School of Neptunists and the advent of modern geology under the lead of such men as Lyell, Murchison, and Sedgwick. A general interest in the subject became apparent after the publication of the geological map by William Smith in 1801 and culminated in the formation in 1807 of another landmark, the Geological Society of London. This body was happy in including amongst its Fellows a numerous band of exceptionally distinguished men and amongst them De la Beche, a co-Secretary with Darwin and later the first Director of the Survey. An extensive traveller, keenly alive to the practical side of the science and, as the author puts it, having "the sense of fathoming the official mind," it was under his skill as an organizer that the Geological Survey of Great Britain came into being. The Museum of Practical Geology followed as a natural sequence, and the hall in Jermyn Street attained a speedy fame through the lectures of Huxley, Tyndall, Stokes, and others.

Thus the leaven spread: doubtless the publication of Lyell's 'Principles' in 1830 did much to help. In 1854 the Museum, the related School of Mines and the Geological Survey were placed under the Department of Science and Art. Later, when Sir Archibald Geikie was Director, they were reorganized by the Board of Education, and, in 1918, were transferred to the Department of Science and Industrial Research.

The evolution of the functions and accompanying vicissitudes of the Survey are ably traced by the author up to the time of the opening of the buildings in Exhibition Road, necessitated, apart from general convenience, by the structural collapse of the old house in Jermyn Street.

During this time the influence of the Survey increased, not least in acting as a training ground for posts, often of the highest importance, both at home and abroad. The prosecution of economic geology, investigations into coal, water supply and the like proceeded side by side with research of more definitely scientific value, such as the elucidation of metamorphism and the oscillations of climate characterizing the glacial period. The introduction of colour printing for maps, of the microscope as an aid in unravelling the tangled skein of petrological subtleties and the attention given to superficial or "Drift" formations, sands, clays, brick-earths and the like, mark stages in the growth. The Fuel Research Station and the Building Research Station, formed by the Department of Scientific and Industrial Research for the study of these subjects indicate how matters of obvious importance have inevitably grown beyond the capacity of the limited staff of the Survey, which in questions of geology remains the final source of information.

The history of the Survey, as briefly indicated here, forms Part I of Sir John's Book; Part II, of subordinate interest, is concerned with the ceremonial opening of the combined Museum of Practical Geology and offices of the Survey in Exhibition Road. The speeches made on that occasion, a list of delegates, a useful staff list, and a bibliography of biographical and historical publications follow, and an adequate index completes the volume. One word must be given to the illustrations: they consist almost entirely of eminent geologists connected

with the Survey. To the reviewer, whose recollections go back some forty years, the majority are excellent. J. P.

DEUTSCHE ATLANTISCHE EXPEDITION AUF DEM FORSchungs- und Vermessungsschiff "Meteor" . . . 1925–1927. Wissenschaftliche Ergebnisse. Edited by ALBERT DEFANT. Band VI. Erster Teil. Schichtung und Zirkulation des Atlantischen Ozeans. Erste Lieferung. 106 *pages*. Das Bodenwasser und die Gliederung der Atlantischen Tiefsee. By GEORG WÜST. (1933.) Zweite Lieferung. iv+109–288 *pages*. Die Stratosphäre. By GEORG WÜST. (1935.) *Berlin: Walter de Gruyter & Co.*, 1933–35. 11×9 *inches; maps and diagrams*

The cold bottom water of the Atlantic Ocean is formed at the surface in high southern latitudes, over the slopes of the Weddell Sea and in some other position which is still uncertain. As it sinks its temperature is raised by compression so that it becomes difficult to follow its course. Dr. Wüst has therefore plotted the potential temperature, that is, the temperature which the water would have if raised to the surface again. The larger part of the water flows northwards through the western trough and can be traced to 36° N. lat., off Bermuda, and even beyond. The eastern trough is obstructed by many ridges and no bottom water passes northwards over the Walfish Bay Ridge. But a small quantity of the cold bottom water passes from the western trough to the eastern through a break in the Central Ridge near the equator, probably at Romanche Deep, and can be followed southwards to Walfish Bay Ridge and northwards to 34° N. lat., in the Canary Basin.

The vertical change of temperature may be very rapid near the bottom; as much as 1·1° C. has been observed over the Rio Grande Rise. The density of the bottom water of southern origin is sometimes less than that of the overlying northern water, a paradox which the author attributes to an error in the "chlorine coefficient" used.

At the time when the *Meteor* sailed Merz and Wüst had shown that there was good reason for believing that the Atlantic Ocean consisted of four layers: the upper warm salt layer to which Defant has given the name of "oceanic troposphere," the cold Antarctic Intermediate Current, the warm salt North Atlantic Deep Water formed chiefly at the surface of the Sargasso Sea, and the Antarctic Bottom Water. Wüst now shows that the structure is much more complicated. He has adopted and extended Dr. Wattenberg's suggestion that a layer with minimum oxygen content occurs between layers of water which flow in more or less opposite directions, since here the movement and renewal are least. He has also drawn "nucleus charts" for each kind of water, which follow the centre of each layer as shown by some characteristic property, such as a maximum of salinity; such charts will be in general curved surfaces. From these he has drawn charts which show the fraction of the original water remaining at any position and thus the spread. This has led to results of great interest. The North Atlantic Deep Current is seen to consist of three parts. The Upper Deep Current is cut off from the surface waters of the Sargasso Sea by the layer of minimum oxygen at the base of the troposphere and derives its high salinity from the outflow from the Mediterranean, as Defant had earlier foretold. It spreads westward in the North Atlantic and then southwards along the coast of South America. The Middle and Lower Deep Currents are formed at the surface in high northern latitudes and are marked by maxima of oxygen.

The direct flow of these five layers of the "oceanic stratosphere" is confined almost entirely to the western side of the ocean, and the water in the central and eastern part is supplied by lateral eddies and similar movements. It follows

that the attempts of Deacon and others to measure the speed of the current by means of determinations of oxygen in a line of stations must fail unless the line lies in the axis of the current.

Three surfaces have been found between the chief currents in which the oxygen, and therefore the movement, is very small. Dynamical calculations of currents are usually referred to a layer which is assumed to be at rest, very often the 2000-m. layer. The layer of minimum oxygen at the base of the troposphere occurs much nearer the surface, and the author points out that such calculations may give rise to misleading results.

These two reports are contributions to oceanography of very great value, and the numerous excellent charts make them easy reading. The author is to be congratulated. D. J. M.

ECONOMIC AND HISTORICAL GEOGRAPHY

A RATIONAL ECONOMIC GEOGRAPHY. By F. L. Fox and G. H. Fairs. *London: The Gregg Publishing Co.*, 1937. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 320 *pages; maps.* 4*s* 6*d*

This is an elementary text-book intended for students preparing for commercial examinations. The plan of the book "is based on the idea of commerce as a piece of machinery which performs three main operations—the Production of Raw Materials, Manufacture, and Distribution." Thus the five sections deal respectively with geographical controls, the production of commercial commodities, mineral production, industries, and distribution. A selection of examination questions is given at the end of each of these sections. The treatment is clear and non-technical, but at times it becomes little more than the recital of names of places and products. This may well be useful for examinees but it may also kill any real interest in geography as effectively as lists of dates kill real interest in history. The statements that the settlement in England of immigrant Flemish weavers "gave rise to the English woollen industry," and that before the early nineteenth century "commerce was concerned mainly with luxuries" need at least modification. The figure of "about a million people" given as employed in the British fishing industry needs dividing by about ten.

A general survey such as this book attempts cannot be exhaustive, but it is a serious omission not to have given any real treatment of the United States Middle West. This area might well have been discussed with the Canadian prairies in Chapter XVIII of Section II. Latitude 49° N. is after all a purely political boundary. Considering the importance of the Middle West in American life this omission seems irrational in even a rational economic geography.

T. S. W.

THE DISCOVERY OF A NEW WORLD (Mundus alter et idem). Written originally in Latin by Joseph Hall, *ca.* 1605; englished by John Healey, *ca.* 1609; edited by Huntington Brown. *Cambridge, Mass.: Harvard University Press* (*London: Oxford U.P.*), 1937. 9×6 *inches;* xxxvi+230 *pages; illustrations and facsimile maps.* 12*s* 6*d*

The discoveries of geographers have in all ages provided materials for philosophical discourses or pleasant burlesques. More's Utopia was closely related to Vespucci's voyages, Bacon set *New Atlantis* in the unknown Pacific, Gulliver travelled to regions about which there was much speculation, and Defoe wrote many stories based on voyages of men like Dampier, Tasman, and Narborough. Joseph Hall selected *Terra Australis, nondum Cognita.* "The Unknowne

Southerne Continent. What good spirit but would greeve at this? If they know it for a Continent, why then doe they call it unknowne? But if it bee unknowne; why doe all Geographers describe it after one forme and site? Idle men that they are, that can say, It is it is, and yet wee know it not." His burlesque, which also has its serious moral side, describes in detail this "unknown" land and its inhabitants, and he makes frequent and very interesting references to contemporary geographical literature. Milton stigmatized it as "a mere tankard drollery," but it is more than that, and it will bring delight to those who care to trace the connection between fact and fiction. Mr. Brown has done much to help his readers with a useful introduction and a most scholarly body of notes, and the work is admirably produced. J. N. L. B.

LOST ATLANTIS. By JAMES BRAMWELL. *London: Cobden-Sanderson*, 1937. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 288 *pages; sketch-map.* 7*s* 6*d*

Having maintained a judicial impartiality between archaeologists, geologists, and anthropologists for one hundred and ninety pages, Mr. Bramwell concludes that "the harder one tries to discover the solution of the Atlantis problem the clearer it becomes that no solution is possible until the sciences upon which it depends become a great deal more developed." Yet after all the arguments for and against the reality of Plato's Atlantis—and none seems to have escaped the author—one is apparently forced to call oneself either "a moonstruck dreamer" or a "blind materialist." Naturally preferring the latter alternative one is confronted in the next chapter—ominously called "Then face to face"—with "the occultist conception of Atlantis." Those readers who can survive this apparent nonsense will find some interesting connections between Blake's *Jerusalem* and Atlantis before they reach Mr. Bramwell's conclusion that spiritual adventure is worth something in a material world. It might be suggested that the "problem" of Atlantis would not have arisen if those who saw a "problem" could evaluate evidence. Who, for example, would accept Solinus as an authority on the supposed once greater extent of the Scilly Islands? Yet the greater part of this book is taken up with a discussion of theories which, at best, are improbable and at worst are fantastic. In his efforts to be fair Mr. Bramwell has shown unnecessary tolerance. The solution of the "problem" is doubtless hidden for ever in the mind of Plato, and one might recall the words of Jowett: "the whole narrative is a fabrication" and "no one knew better than Plato how to invent 'a noble lie'." J. N. L. B.

GENERAL

THE MOUNTAIN SCENE. By F. S. SMYTHE. *London: Adam and Charles Black*, 1937. 11 × 8 *inches;* x+154 *pages* (*inc. 78 plates*); *illustrations.* 12*s* 6*d*

Mr. Smythe tells us in his preface that he has read nothing about the finer points of photography. Nevertheless he has evidently given the closest study to his art, and the results which are here revealed show both a skilful hand and a discerning eye. The opening chapter on photographing the hills contains valuable advice to the amateur photographer, and this advice is elaborated in the text which accompanies each picture. Mr. Smythe has cultivated his natural gift of selecting a fit subject; his choice of foreground deserves special commendation, and he is at his happiest in seizing some momentary cloud effect or in conveying the impression of depth, as is magnificently illustrated in the early morning views from Matterhorn and Weisshorn on Plates XXXVII and XXXIX.

The pictures are naturally the main interest of the book, but the letterpress also calls for comment. The author has had a difficult task in combining a description of the scene with practical hints and criticisms of his own work, and it would have been better to keep these items always in separate paragraphs. The style is for the most part simple. There are a few mistakes in names, no logical system in the spelling of German words, and on Plate XXVI the Matterhorn is wrongly identified.

On p. 92 there is an ambiguous phrase which may suggest that Mr. Douglas Freshfield recommended tackling Kangchenjunga from the north-west. Mr. Smythe must be familiar with Mr. Freshfield's exact words, which the latter restated in the *Alpine Journal*, vol. XLIII, p. 426. The second point is the statement that the political difficulties of approaching this mountain are now greater than they used to be, "due I suspect to the large elaborate expeditions that have impoverished the Himalayan peoples during the past few years." This is a serious charge, coming from so distinguished a traveller and writer as Mr. Smythe, and it should not have been inserted thus casually in the middle of a sentence without any evidence in its support. One may remind the author that the Nanga Parbat Expedition of 1932 was compelled, in the interests of the native population, to abandon the direct route by the river valleys and to cross three subsidiary ridges in approaching the mountain.

The fact that all the photographs come from one artist adds greatly to the unity of the book, and it is to be hoped that another volume, composed from the many thousand negatives out of which these seventy-eight plates have been selected, may soon appear. H. E. G. T.

AUTO: Fahrten und Gefährten. By ALFRED GRABER. *Zürich-Leipzig: Orell Füssli*, 1937. 8×5 *inches; 186 pages; illustrations. Fr.4.50; M.2.70*

Herr Graber, a well-known Swiss writer, is the author of this brief and attractive book on motoring. A car is for him something more than a vehicle: it becomes an integral part of his being. The sketches include a light-hearted account of his early motoring experiences, and his own country is the scene of many of them. Some of his tours however took him farther afield, to Africa, Dalmatia, and Greece. They brought him many friends and pleasant adventures; and it is clear that, though he was lucky enough to be a motorist, he never entirely regarded motoring as an end in itself. J. P. H. M.

THE MONTHLY RECORD

EARLY METEOROLOGICAL CHRONOLOGY

Under the title of 'A Meteorological Chronology to A.D. 1450' Mr. C. E. Britton presents a scholarly compilation of remarkable meteorological events recorded in the British Isles in early times together with a complete list of the historical material, much of it of course in Latin, upon which it is based. (*Geophysical Memoirs*, Meteorological Office. Air Ministry. No. 70, 1937.) Tribute is paid to the excellent Roll Series of manuscripts of the Royal Historical Society, which includes the well-known Anglo-Saxon Chronicle, and there is a lengthy discussion of the faults and merits of the immense treatise of Dr. Thomas Short, of Sheffield, who in 1749 published his 'General Chronological History of the Air, Weather, Seasons, Meteors, etc.' In the "traditional period" before the coming of the Romans we find entries referred to dates as far back as 2688 B.C., but no accuracy is claimed for those dates which are taken from the Irish annals, chiefly with reference to eruptions of the Irish lakes. During the Roman and Saxon periods the historical authenticity of dates and events is of course greater and from the ninth century the notices of meteorological events are of sufficient detail and reliability to allow of amplified annotation. The date 1450 at which the chronology ends was chosen arbitrarily, but it coincides with the era of the invention of printing and the beginning of a definite expansion of the sources available for examination.

Under date "1287. Marine floods on December 17," we find a vivid account of the inundation by the sea in the middle of the night of the Norfolk Broadland with the loss of hundreds of lives at Hickling, Horsey, and other villages as far as Yarmouth. In modern times the sea has been known to breach the sand-hills which hem in the Norfolk Broads and there were serious inroads during the bitter north-easterly gales of January 1897.

A large number of the entries are entertainingly described, reflecting the customs, beliefs, and superstitions of the times; but owing to differences in literary styles and to the hyperbole of early writers it is difficult to assess the actual magnitude of the floods, droughts, storms, frosts, and snows in comparison with noteworthy events of the present day. Mr. Britton has produced a valuable and interesting compilation which will be the standard authority for the period and area covered.

THE ORIGIN OF THE PORTOLAN CHARTS

In his brief monograph, 'Hallucinations scientifiques (Les portulans),' Leiden, 1937, Prince Youssouf Kamal characterizes as "hallucinations" two contentions: first, that anything regarding the origin of the portolan charts has been, or can be, established; the second, that the charts owed anything to Arabic influence. As he proceeds to state his views on their origin, it is to be presumed that the second is in his eyes the major "hallucination." The author does not discuss his contentions at great length, or very systematically, but it is possible to summarize them briefly. The absence of windroses and lines of latitude and longitude should not be taken as evidence of the antiquity of a particular chart. It is impossible to navigate by the compass alone, so that mediaeval sailors in the Mediterranean must have used instruments similar to a sextant or gnomon. The compilers of the early portolans were not concerned with navigation at sea, but concentrated upon the configuration of the coasts and the dangers surrounding the anchorages. The net-work produced by joining-up the centres of the windroses may have indicated relative astronomical position,

this grid having originally no connection with the windrose. He suggests elsewhere that this grid may have been retained to simplify copying. To endeavour to relate the compass rose to the chart is to credit the latter with an astronomical character which it does not possess. In essence, the chart was a representation of the written portolano. As to Arabic influence upon the origin of the chart, the author dismisses this completely, and argues that the Western nations were capable of evolving it to meet their special needs.

In denying the influence of the compass upon the evolution of the chart, and regarding it as a development of the earlier written sailing directions, the author ranges himself with Dr. Uhden (see *Geogr. J.* 87 (1936) 90). He admits that his theory will meet with considerable objections. It is difficult to accept the argument that the contemporaneous evolution of the chart and the perfecting of the compass were merely a coincidence. The earliest evidence for the use of a quadrant for navigation at sea dates from the mid-fifteenth century.

DIAMOND FIELD IN SIERRA LEONE

In the *Bulletin* of the Imperial Institute for October 1937, Mr. J. D. Pollett relates the history of the recently discovered diamond field in Sierra Leone, which is already one of the world's principal fields. The first find was made in January 1930, when a geological survey party found two small diamonds in the alluvial flats of the Gboboro stream, Kono District. The discovery attracted little attention at the time, but in March 1931 a prospecting party arrived from the Gold Coast. By 1932, it had been proved that fields of undoubted economic value existed in the Colony, and a company was formed under the licence of the Sierra Leone Government with the sole rights to prospect for diamonds. The richest deposits have been found in the gravels of the River Sewa and its tributaries, and a permanent mining camp has been established near the village of Yengema. All classes of diamonds are found, from those known as "bort," used for industrial purposes, to fine quality gems. The value of the deposits varies considerably, and also the size of the diamonds. One stone weighing 78 carats has been found. The stones are finally classified in London, and sold through the trade marketing organization. In the year 1932–33, the value of the sales was £4500; by 1935–36, it had risen to £500,000. It is considered that the stones are of local origin, though they have not yet been discovered *in situ*.

SHORE FORMS OF LAKE OLGA, QUEBEC

In the *American Journal of Science* for June 1937 Mr. J. W. Butler contributes a paper entitled "Boulder beach cusps, Lake Olga, Quebec." These features were observed during the summer of 1935 on the north-east shore of the lake some 100 miles south of James Bay. Their peculiarity was the extraordinary size of component fragments especially as compared with the relatively small dimensions and spacings of the cusps themselves, which measured about 18 feet at their base and 9 feet from base to apex. They were not triangular accumulations of débris but short, low ridges and troughs perpendicular to the shore-line. The field evidence suggests wave action, not ice-thrust or rainfall run-off, as the agent concerned in the formation of the cusps. The dimensions and spacings of the cusps however indicate that they were formed by waves too small to transport the boulders composing them, so that they must have developed under unusual conditions. From the tideless character of Lake Olga it is clear that tides are not necessary to the formation of beach cusps, though some investigators consider they are much more potent than waves.

The Lake Olga boulder type of cusp, which is very rare, is believed by the author to be due to selective erosion of bouldery glacial drift by waves that

strike the beach most of the time during the ice-free season. Such waves are less than one foot high, and are unable to transport all the component material directly; but they can undermine and lower the boulders, thus retrograding the beach and concentrating the boulders. The cusps, apparently, begin to form when the waves erode certain places on the bouldery beach a little deeper than adjacent areas and thus develop shallow basins flanked by cusp ridges. The spacing of these would be at random at first, but eventually the intercusp areas would approach each other in size and spacing when the selective erosion in adjacent troughs reached an equilibrium governed by the size of waves striking the shore most of the time. This explanation of the Lake Olga boulder cusps recognizes that their development will end when boulders have become so concentrated that no significant amount of fine interstitial material can be removed by erosion. It is pointed out that, whereas sand and gravel beach cusps built by waters subject to tides move up the beach with the rising tide and are left behind by the ebb tide, and those built by storm waves on lake shores are driven above the shore line of calmer water, the Lake Olga cusps have a relatively stable character. Fluctuations of lake level would not interrupt the regular work of waves, but would gradually expose higher or lower portions of the beach to their action.

CHINESE RICE FARMERS IN HAWAII

The history of rice cultivation in Hawaii is examined by J. W. Coulter and C. K. Chun in a recent research publication of the University of Hawaii. Experiments in rice growing were begun between 1858 and 1862, but it was the gradual transference of Chinese labourers from the sugar cane plantations that contributed to the growth of the industry, and their numbers rapidly increased through unrestricted immigration. The decline of the native taro industry left large areas of suitable land available, and much previously unused swamp land was also brought under cultivation. The discovery of artesian water supplies further contributed to the expansion. Between 1878 and 1884, the number of Chinese increased from six to eighteen thousand. The factors favourable to the growth of the industry were: the unrestricted labour supply; the increasing number of Chinese in California, the export to this market being favoured by a reciprocity treaty with the United States in 1876; and the ability of the Chinese to organize the industry on co-operative lines. The industry reached its height in 1909, when over 9000 acres were under rice. At that date however it reached a crisis, on account of the restriction on immigration, the result of the annexation to the United States in 1898. The fiscal policy then followed encouraged the growing of sugar in preference to rice, and the exports also encountered increasing rice production in the United States—the first commercial rice crop in California was grown in 1912. The introduction of modern mechanical methods has also affected the Hawaiian industry. Thus the total area under rice in 1936 had declined to 1275 acres, and the industry is rapidly dying out.

The monograph contains an interesting account of the methods employed in raising the crop, and of the social and religious organization of the settlers on farms and plantations.

OBITUARY

GEOFFREY SWINFORD LAIRD CLOWES

We record with much regret the death of Mr. G. S. Laird Clowes on July 19 last. He was the only son of Sir William Laird Clowes, the naval historian, from whom he inherited his interest in ships and the sea. Educated at Aldenham and Sydney Sussex College, Cambridge, he joined the Survey of Egypt in 1906, retiring in 1924 with the rank of Chief Inspector. During the war he served in the Near East in the Royal Engineers, and later as Political Officer. On his retirement, he joined the staff of the Science Museum, becoming Assistant-Keeper in 1932, and was charged with the care of the National Ship Model Collections, which he developed with ability and judgment. He was the author of a number of publications on the history and technical development of sailing ships, and a member of council of the Society for Nautical Research.

Mr. Laird Clowes joined our Society in 1923, and with his wife was a regular attendant at its meetings. In 1927 he read a paper on the ships of famous explorers at an afternoon meeting. His technical knowledge was readily placed at the service of inquirers. From 1933 to 1935, he served as president of the Kosmos Club, an office for which his pleasant personality, his interest in the work of the Society, and his reminiscences of experiences in Egypt, well fitted him.

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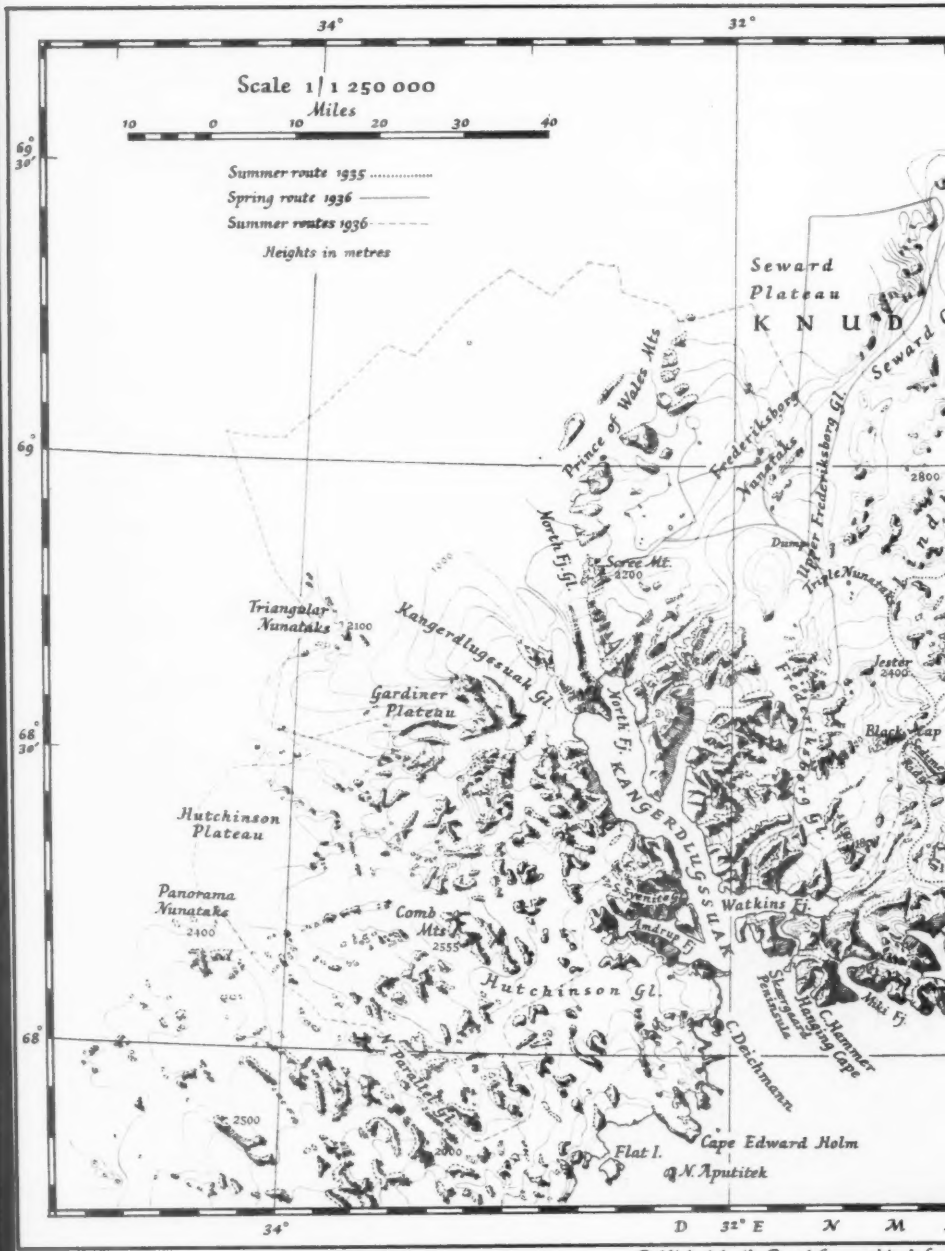

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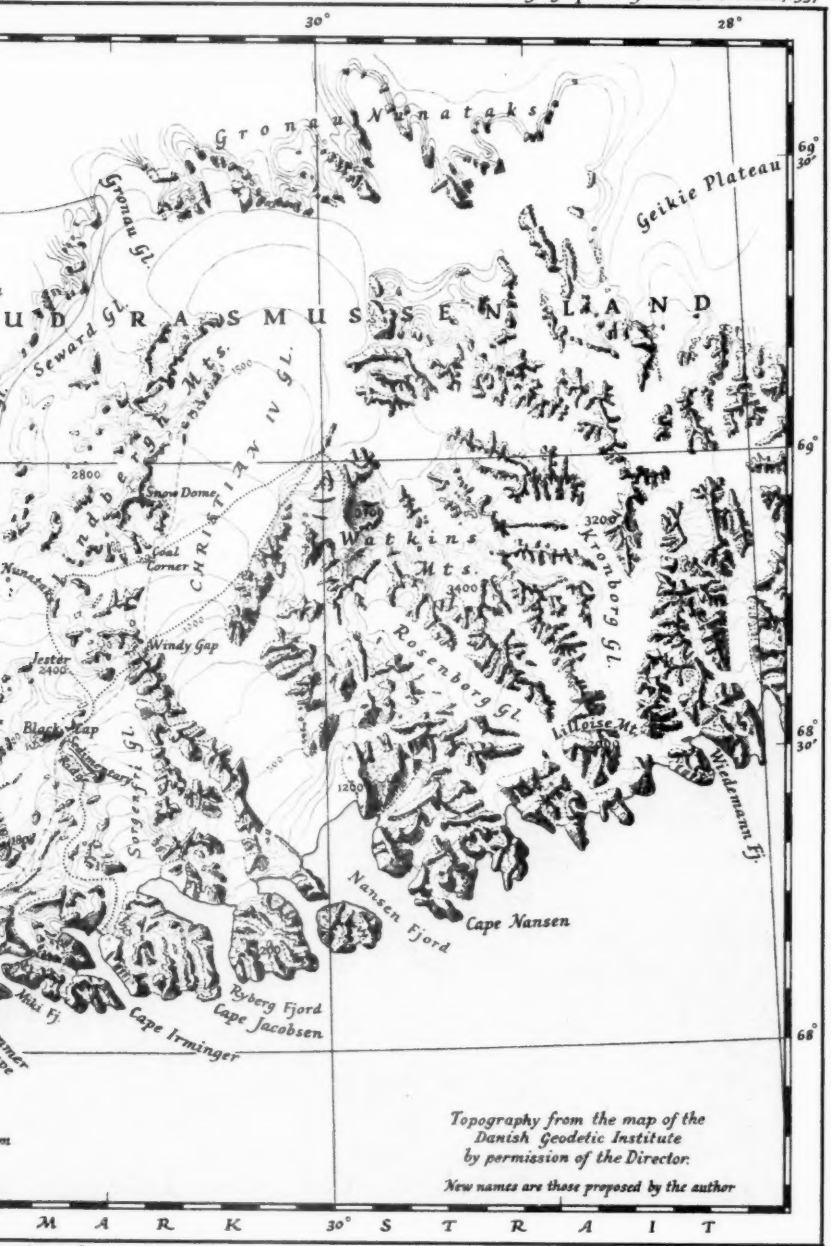

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